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CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

COOPERATION BETWEEN SOVIET, AMERICAN COMPUTER SCIENTISTS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 19 Oct 77 p 3

[Interview with Robert Schmidt, first vice president of Control Data Corporation, in Leningrad, by B. Bannov]

[Text] Representatives of the American firm, Control Data, have held discussions in Leningrad with a group of Soviet cybernetics scientists. The American delegation was headed by Robert Schmidt, first vice president of Control Data. Upon a request by SOTSIALISTICHESKAYA INDUSTRIYA, the Novosti correspondent, B. Bannov, held an interview with R. Schmidt which is published below.

[Question] What is the objective of your present visit to the Soviet Union, Mr Schmidt?

[Answer] We have come to meet with Soviet scientists from the Academy of Sciences for the purpose of discussing new types of computers, determining paths of cooperative work on new EVM's, and looking into the possibility of our participating in this work. Such is the primary objective of our visit.

[Question] What would you say about the development of the computer industry in the Soviet Union?

[Answer] Control Data has purchased a "Ryad-40" computer from a series of computers produced in the CEMA nations and has installed it in our Vienna office to process current information. We were faced with the problem of how we could connect this computer and other machines of the "Ryad" series to our international network of "Cyber" computers. We came to the conclusion that the technological level and execution of the Soviet computer was very good. This machine is reliable to a high degree. It is equivalent to our own equipment or the equipment of IBM.

I managed to visit a series of Soviet enterprises producing semiconductors. In Leningrad, I saw work in the area of integrated circuits. This is extremely high quality work. The products of the Svetlana firm, their

technical characteristics and quality are not inferior to those of the West. I also visited a computer plant in Minsk and saw the production and testing of the "Ryad" computer series. It is a modern plant producing an excellent product.

I was able to confer with Soviet scientists from the Academy of Sciences and from various institutes throughout the country. I was greatly impressed by both these scientists and the results of their work.

The leadership in the Soviet computer industry is very dynamic. These people are doing everything they consider necessary for the strengthening and development of the electronic computer industry.

[Question] A number of enterprises are involved in supplying computers to the Soviet Union. What could you say in this regard?

[Answer] In light of detente, I think that the United States is applying too harsh a restriction in the area of exports. And these restrictions, in both my own opinion and that of Control Data (of course, I am not speaking for the American government), are hindering trade between the Soviet Union and the United States. This harsh, restricting policy being carried out by us in the United States, is having a negative influence on employment. The manufacture of each "Cyber-76" computer intended for your country, for example, would provide jobs for 500 workers in the United States. As is well known worldwide, we are suffering badly from unemployment. And we could use this export and the improvement of trade relations with the Soviet Union to alleviate the problem.

One overzealous congressman, who came out against granting us a license to supply our "Cyber-76" computer to the Soviet Union, charged Control Data and its chairman with high treason. This is, of course, ridiculous. We are capitalists and do everything to benefit our country.

[Question] How in your opinion will the further deepening of international detente affect the future development of Soviet-American cooperation?

[Answer] We believe that the easing of tensions, limiting the arms race and trade with the Soviet Union will further the United States' position. We must trade. I believe that the rate of this trade, which we could successfully conduct if we followed a different policy, would double and triple in a short period of time. I am an optimist. But I am also a pragmatist. We have long been isolated from one another. And although our rapprochement will not be as lengthy as our isolation, nevertheless it will not happen quickly. But I believe that the present administration, when it has had enough time to carefully appraise the U.S. position on the questions of easing tensions, arms limitation and trade with the Soviet Union, will adopt a positive line.

We have undergone several small traumas since the new administration came to power. But I sincerely believe that the situation will soon change.

I heard that President Carter said at the signing of a new agreement between the USSR and the United States on cooperation in the fields of science and technology that we would continue our joint efforts in science and technology. He said this publicly, so it is not only my opinion.

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CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

INTEGRATED COMPUTING FACILITIES PROPOSED IN LENINGRAD INDUSTRY

Leningrad LENINGRADSKAYA PRAVDA in Russian 19 Nov 77 p 2

[Article by G. Krayukhin, doctor of economic sciences, prorector for scientific work of the Leningrad Engineering-Economic Institute imeni Palmiero Togliatti, and V. Obukhov, candidate of technical sciences and senior scientific associate: "Concentration Is the Path to Efficiency"]

[Text] In recent decades many scientific discoveries have swiftly found their way to our shops, laboratories, and everyday life. Atomic reactors have become a source of electric energy. Lasers have opened a new page in technology. Semiconductor instruments have provided impetus for the development of communications and computer equipment.

Many problems have been encountered on the path to these and other achievements of the scientific-technical revolution. Perhaps one of the most complex problems has proven to be the problem which now stands in the way of extensive use of electronic computers.

This conclusion may appear paradoxical. In fact, one or even several computers are now employed at virtually every enterprise in Leningrad. Researchers and designers cannot imagine making their calculations without computer equipment. Each year our stock of computers increases and specialists are already ordering third-generation machines produced by the CEMA countries: the YeS-1022, YeS-1030, and YeS-1060. They are receiving these modern, high-speed devices with their colossal electronic memories and...becoming disillusioned.

No, the machines do work; they stun the imagination with their capacities. But put yourself in the place of an enterprise director who has paid several hundred thousand rubles for the latest model of computer and is spending money for its operation, to maintain the staff, and for program development but, with all this, receives a very modest return or none at all. Then you will understand the substance of the disillusionment.

One is struck by a certain fact. Where computers are used for scientific calculations and modeling complex processes their benefits are obvious and considerable. But in production control systems and processing operational economic information, in a large majority of cases their efficiency does not bear out our hopes.

This juxtaposition illustrates the basic problem which specialists encounter when first introducing computer equipment: a discrepancy between the organizational foundations of computer use and the level and capabilities of the electronic computing equipment itself.

In recent years production control has undergone major changes. Enterprises are being consolidated and associations formed. The party has challenged our Soviet land to sharply raise work efficiency and quality, and already the first steps toward realizing this program have been marked by significant improvements in national economic management.

During just the Ninth Five-Year Plan more than 2,000 automated control systems were launched in the country. In Leningrad industry their number increased by more than 100. The aktiv of the Lenelektronmash Association, a pacesetter in development of automated control systems, now has qualitatively new methods of designing such systems and a vast program for introducing them in the Tenth Five-Year Plan. Nevertheless, the principle for solving these problems has remained unchanged. Despite the new computer equipment, despite the changes in the organizational structure of industry, and despite improvement in programming methods, automated control systems suffer from lack of system.

Of course, any production unit represents a single organism. The designing of articles is closely tied to production technology, organization of labor, and economics. All the shops and services are similarly interrelated. But when setting up and introducing automated control systems each of these production areas is taken separately and in isolation from the others.

What is the result? While talking about the comprehensive approach, already in the stage of setting up the automated control system we are turning the system into a set of many disassociated solutions. At many enterprises the ASU's [automated control systems] solve only a few dozen problems, but this is spoken of as if it were perfection; in fact, we should speak of the system's dispersion and duplication of problems and, therefore, its overall low efficiency.

For example, take the calculation, estimation, and control of prime cost in any ASU. The index of prime cost is set up in the planning stage and then passes through all technological processes and is invariably included in the solution of problems of economic organization. In practice this index is repeated 100 times and more in the automated control system. The same thing happens with the index of product quality and with many others.

But if we go outside the framework of the ASU of a single enterprise, we will see that the computer equipment at the neighboring enterprise is solving the very same problem and coming to the very same conclusions, but it requires its own separate staff of programmers, computer operators, and mathematicians. But that is only a beginning. Then there must be careful work stretching out over several years to compile the data base, which in large part repeats the work of other developers.

Five years ago specialists began raising a hullabaloo about the need to set up collective-use computing centers. The country now has several such centers and they have been set up in Leningrad. This idea has gained recognition and its benefits are real: an increase in the efficiency of computer use.

But when we talk about the efficiency of not just the electronic equipment but of the control systems themselves we must look somewhat beyond the group computing centers.

The Metal Plant, Neva Plant, and Izhora Plant are three very large power machine building associations. Each of them has an ASU based on second-generation computers and a well-staffed computing division. The ASU's bring a definite benefit, but they do not pay for themselves.

Big changes are now underway at these associations, related to the incorporation of new products, improvement of production technology, and organization of production. Work is also planned in the area of automated design, control of production processes, and the like.

But when ASU developers begin analyzing the activities of the three enterprises they see how much there is in common among them. More than 60 percent of all design jobs are identical. Indeed, can the calculation of shafts and gears at the Izhora Plant differ from the Neva Plant's calculations in the same field? Is there a great difference in projects to introduce group technology and control production processes? Aren't the solutions to problems of marketing, finances, supply, personnel, and the like at all three enterprises the same?

There are many other enterprises in Leningrad industry which are similar in technology and production organization. For example, take ship building; there we have the Baltic, imeni Zhdanov and Admiralty Association shipyards. Or look at instrument making enterprises, or the numerous factories in the textile, knitted goods, and garment industries. By establishing unified computing centers for such related plants or factories and eliminating duplication in solving identical problems we would receive a uniform automated control system for several enterprises, an "integrated" system as the specialists say.

The idea of such systems has been discussed more widely by specialists recently. It has now gone beyond academic discussions and proposals. Not long ago our institute completed a project ordered by Lenelektronmash and the USSR Ministry of Power Maching Building which took several years.

The purpose of the project was to determine the possibilities of integrating ASU's. As a result we not only substantiated the idea of such consolidation but also created a structure for an integrated ASU (an "IASU") and made analytic calculations.

These calculations show that combining computing centers and integrating automated control systems is the chief path to raising system efficiency in the current stage of development of the electronic equipment industry. One should not think, of course, that IASU's will consolidate the direct management of enterprises and diminish the role of their managers. There was a time when large plants had their own power stations. Centralizing the delivery and distribution of electricity improved and simplified this aspect of the work. Centralization of computer equipment will have the same result.

One also should remember that the continuing establishment of sectorial systems and preparations for the nationwide automated control system depend largely on consolidating the ASU's of individual enterprises. So the idea of integration today is not just desirable but also necessary.

But what is the next step toward realization of the idea of the IASU? At the present time, for example, the Izhora Plant, Metal Plant, and Neva Plant associations are concluding contracts with numerous higher educational institutions in Leningrad to perform particular problems with new automated control systems. It seems to us that if the goal is the creation of an integrated system this work must be carried out on a cooperative basis by the various higher educational institutions with participation by the Lenelektronmash Association, the Ministry of Power Machine Building, and specialists from the enterprises themselves. Perhaps the experience with creative cooperation accumulated by the collective participating in building the Sayano-Shushenskaya State Regional Hydroelectric Power Station should be made the basis for organizing this research and development. The problem is quite complex; our country as yet has no experience with setting up integrated control systems, and concentrating efforts will help solve it as quickly as possible.

The 25th party congress emphasized that further expanding the use of computers in our national economy and raising the efficiency of their operations constitute a challenge equal in importance to the development of electric power. Improving production control is inconceivable without improving the ASU's themselves. And they must develop along the optimal path.

11,176
CSO: 1870

CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

UNIFORM RATES FOR COMPUTING JOBS, SERVICES NEEDED NOW

Moscow EKONOMICHESKAYA GAZETA in Russian No 47, Nov 77 p 9

[Article by V. Maksimenko and V. Simchera, doctors of economic sciences:
"Uniform Rates for Computing Center Services"]

[Text] Considerable experience has been accumulated in the national economy with using computers to solve various problems of accounting, planning, and management. This work was begun back in the Eighth Five-Year Plan. In the years since then roughly 3,000 ASU's [automated control systems] and more than 2,700 computing centers of different designations which solve more than 250 scientific and applied problems have been put into operation in the Soviet Union. The automated systems today are performing, in addition to the common, standard problems, important nonstandard problems of optimal planning and management.

The document "Basic Directions of Development of the USSR National Economy for 1976-1980" poses the challenge of securing further development and improvement in the efficiency of automated control systems and computing centers while consistently joining them into a single nationwide system for the collection and processing of data for accounting, planning, and management.

Solving this problem and further improvements in production using computers today depend largely on improving the organizational-economic mechanism of functioning of ASU's and computing centers, above all on the prices and rates for their work and services.

The Components of the Cost of Information

The solution to this important problem acquires special significance where existing computing centers are being switched to economic accountability (and more than 500 of the 2,700 operating computing centers today have been switched to these working conditions). The point is that in the coming years work will be done to establish collective-use computing centers which are the most efficient form of use for computer equipment.

Substantiating the prices and rates for computing center work and services assumes a determination of the true cost of the information itself. Under our conditions, it seems to us, this cost is equivalent to the socially necessary expenditures for collection, processing, storage, and transmission of information.

Some experience has been accumulated in the past with establishing prices for ASU work and rates for computing center services, in particular experience with applying agreed-upon prices and rates determined by calculating the prime cost of computing jobs. Introduced by departmental orders and fixed in annual contracts for computing jobs, these prices and rates became a kind of norm in the work of economically accountable computing centers of the USSR Central Statistical Administration, USSR Gosstat, USSR Sel'khoztekhnik, and numerous departments which perform computing jobs for outside enterprises and organizations. As a rule, such rates are set overall for a machine-hour of use of different computer groups without any differentiation by classes of computers used or the nature of the jobs performed. The computing centers of the USSR Central Statistical Administration system are an exception; in addition to payment per machine-hour they also have established separate rates for the development of algorithms and programs.

What Experience Shows

The experience gained at Glavmosavtotrans [Main Administration of Motor Vehicle Transportation of the Moscow City Executive Committee] with setting prices for computing work is unquestionably interesting. Unlike most other computing centers they attempted to establish differentiated prices and rates for particular types of jobs. Separate calculations were made for the cost of preparing machine data carriers, one machine-hour of computer use, solving problems, planning shipping by daily assignments at the level of motor vehicles enterprises, and operational planning for ongoing repair of the fleet.

A significant amount of work has been done at the Latvian SSR Gosplan and State Committee for Prices. They have developed proposals for differentiating existing rates for the services of computing centers by establishing percentage supplements to the basic rate for a machine-hour of computer work.

A draft "Price List for the Development and Debugging of Software for Computing Complexes" has gone through experimental testing at several enterprises of the Ministry of the Communications Equipment Industry and has been submitted for discussion. Rates for data transmission have also gone through experimental testing and been recommended for practical use and the USSR Ministry of Communications is working out proposals to set rates for paid data storage and certain other types of services.

When substantiating rates for computing center services a study of foreign experience, which reinforces positive initiatives in this field or

contains examples for borrowing, is also of practical importance. On 1 January 1973 by decision of the Federal Department of Prices of the Czechoslovakian SSR the "Price List of Wholesale Prices for Computer Jobs and Services" was instituted which sets uniform nationwide wholesale prices for these services and establishes a procedure for setting such prices. On 1 January 1977 a new method of calculating the cost of jobs and price lists for computer jobs went into effect in the GDR.

An analysis of accumulated experience with setting prices and rates for the services of computing centers and the work of ASU's in different sectors of the national economy which was made at the All-Union Scientific Research Institute of Problems of Organization and Management of the State Committee for Science and Technology showed that a need has arisen to work out uniform nationwide rates for computer services and uniform price lists for ASU work, insuring identical conditions of efficient work for all information services regardless of their status, the nature of the work, and their departmental affiliation.

Regardless of Their Departmental Affiliation

A proper solution to these problems, it seems to us, assumes successive development of:

1. a national classifier of computing center and ASU jobs and services for each of which it is assumed that separate prices and rates will be set and differentiated calculations with customers made;
2. model standards for jobs and price lists for services and model norms for expenditures of time and capital for technical servicing of ASU's and computing centers, including norms for depreciation deductions;
3. uniform methodological principles for calculating prime costs and determining prices and rates for ASU and computing center jobs and services and a standard procedure for reviewing them.

Some steps have already been taken to solve problems in each of these groups. For example, the All-Union Scientific Research Institute of Problems of Organization and Management has developed and submitted for discussion a draft "Uniform Classification of ASU and Computing Center Jobs and Services." According to this draft all jobs and services are subdivided into 10 groups in each of which there are, in turn, 10-12 specific types of work. In all the classification contains a list of more than 105 different jobs and services. It is assumed that in the future appropriate prices and rates must be substantiated and set for each type of service. Differentiated service to customers is being expanded under these conditions.

The State Committee on Labor and Social Problems jointly with the State Committee on Science and Technology has begun a project to straighten out practices in setting labor norms at computing centers.

The appropriate institutes have been assigned to work out "Uniform Norms of Time (Output) for Jobs Performed on Punched Card, Key punch, and Electronic Computing Machines" and "Model Norms of Expenditures for Technical Servicing of Computing Centers."

A great deal of work is being done to summarize and analyze long-standing sectorial norms, which are considered to be the basis for the development of uniform standards; standards for material expenditures are being worked out. Work being done by the State Committee for Science and Technology to apply the "Statute on the Socialist State Production Enterprise" to existing computing centers will be very useful because it creates the foundation for solving the entire set of problems associated with setting uniform prices and rates for the services of computing centers.

The head organization for the development of prices and rates for computer jobs and services is the All-Union Scientific Research Institute of Problems of Organization and Management of the State Committee for Science and Technology. It is expected to concentrate the efforts of leading organizations on comprehensive solutions to these questions with due regard for the development of a uniform classifier of computer jobs and services and uniform standards for performing them.

On 1 January 1977 a nationwide price list of prices for computing center services was put into effect. It envisions uniform rates of payment for a machine-hour of computer use by types of computers. The price list was ratified by the State Committee for Science and Technology with the agreement of the USSR State Committee on Prices and it applies to all computing centers regardless of the nature of their work and departmental affiliation as well as to other organizations which have and operate computers on the same principles. Unlike past practice, separate rates of payment are set for machine-hours by types of computers:

Type of Computer	Rate of Machine Hour of Use (Rubles)
Minsk-22, Ural-14	30
M-222, Minsk-32, BESM-4	35
YeS-1020	80
YeS-1022	85
YeS-1030	90
YeS-1033	100

The rates are set on the basis of average sectorial expenditures associated with maintenance of personnel for technical servicing of the computers and operating standard software, depreciation of equipment, expenditures for materials, and electricity, and maintaining and renting quarters for the computing center. The price list has been

introduced on a temporary basis and will be in effect until January 1979.

Of course, this price list is only a beginning. Ahead of us, in addition to further improvements in the established payment for a machine-hour of use of different computers, there will be a great deal of work to determine and ratify prices and rates for other important types of computing center jobs and services, including writing algorithms and programs. As group computing centers and collective-use computing centers are launched the list of such jobs and services is expanding. For this reason the All-Union Scientific Research Institute of Problems of Organization and Management, jointly with interested organizations, is carrying on a project to substantiate prices and rates for certain most important types of such jobs and services.

A draft "Statute on Computing Centers" and the "Draft of Methodological Instructions for Setting Up Economic Accountability and Planning the Work of Computing Centers" are being developed; prices for peripheral equipment and tables of organization for different categories of ASU's and computing centers are being put in order. A new incentive system for assigning the work of existing computing stations and financing the production and application of computers is being substantiated. These and other projects are closely related to the projects mentioned above and are aimed at backing them up.

There is no doubt that the efficiency of many solutions in the field of the production and application of computers in the Tenth Five-Year Plan will depend largely on practical implementation of sound prices and rates for computer jobs and services and the extent to which these prices and rates stimulate the work of ASU's and computing centers that are already established and those now being set up. This makes it essential to step up their development and practical scientific testing.

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CSO: 1870

CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

PROBLEMS OF COMPUTING CENTERS DISCUSSED

Moscow GUDOK in Russian 16 Nov 77 p 2

[Letter by G. Mel'tser, chief of the division of statistical accounting and records of the Vitebsk Rail Section, and comment by I. Kharlanovich, deputy chairman of the Scientific-Technical Council of the USSR Ministry of Railroads: "Problems of Computing Centers — Records and Economic Accountability"]

[Text] With this the editors conclude discussion of the article "Double Bookkeeping" which was published in GUDOK on 19 November 1976. Today we are publishing a letter by the chief of the division of statistical accounting and reporting of the Vitebsk Section of the Belorussian Railroad and a comment on it.

[Letter by G. Mel'tser]

Each day employees of the accounting division must collect a mass of data by telephone from all subdivisions, summarize these data, and derive this or that index. This is extremely labor-intensive and painstaking work. That is exactly why people who do it have a great interest in setting up operational accounting using computers.

Programs are being developed and the latest computers installed, but how much easier is the work? In the opinion of many of my colleagues, "The computing center is a pain in the neck."

Formerly the accounting divisions transmitted summary data to the operational divisions of the services of the railroad administration by telephone, but now one "small" technological link has been added to this work: compiling a set of layouts and transmitting them to the computing center. On most railroads the computing center programmers have emphasized delivering operational information to the road management.

On the Belorussian road a different approach has been taken to this matter. The summary part of the load by kind for the 24-hour report period

is sent to the computing center on a special layout. In its turn, the computing center provides the sections of the road with information on fulfillment of the state workload plan (the plan, fulfillment for the 24 hours, average daily workload, percentage of fulfillment, and whether the plan has been surpassed or underfulfilled in absolute terms, cars and tons, from the start of the month). The same system is used for other types of reporting. It is absolutely accurate. Receiving these data has already made it possible to stop keeping various auxiliary logs.

Needless to say, it is not so simple to switch immediately to operational work records using the computer. We developed a dynamic model of the operations of the section.

For example, take records of loading and unloading. A data concentration point has been set up in the division of statistical accounting and reporting and the operators of the freight division have been made subordinate to it. There are data points with direct access to the computing center at all major freight stations.

In the Vitebsk section today the report on work for the preceding 24 hours drawn up by the division takes just one page whereas other sections require 9-12 pages. The directors of our operational divisions receive all other information from the computing center.

I believe that the fact that computers are not used that efficiently in many places is entirely because of ignorance and lack of initiative. In my opinion the chief barriers are organizational-management squabbling and frequently also elementary incompetence.

It is possible to have the most highly sophisticated development of the problem and the necessary data base but still work ineffectively. This is because mental inertia stands in the way. On numerous roads, for example, the divisions of specialized loading of the traffic services have begun using accounting cards for each freight shipper. And while information is maximally concentrated in the computer, still everything is transmitted by telephone to the traffic service. We get a paradox. In one building on the fifth floor they have, for example, summary data on loading, while on the third floor they keep thick logs and enormously long forms filled with charts of loading work where, once again, the results are entered and calculated. What is the difference? The difference is that they are accountants on the fifth floor and traffic service workers on the third floor.

My opinion is clear: the more work the computing center takes on, including accounting questions, the more advantageous it is to us all. And any stimuli to this end are justified. And to switch these subdivisions to economic accountability would be even better.

[Comment by I. Kharlanovich]

There was a debate three or four years ago on the issue of switching the just-emerging computing subdivisions to economic accountability. The basic documents were even worked out: a "Statute on Economic Accountability," cost calculations, work measures, and estimated rates. Needless to say, these documents were developed on the basis of directives from the corresponding departments. The U-01 price list, ratified by the State Committee on Prices for accounting and computing subdivisions, was adopted, for example.

Since that time the question has remained "open." We knew of no similar cases. And the volume of work of our road computing centers was determined not by output produced, but by the plans and tasks developed by each road. This proved to be an obstacle to switching computer centers to economic accountability.

Let me say immediately that today it is not only advisable but really essential to switch computing centers to economic accountability. As we know, there is now a decision from directive agencies to apply the "Statute on Socialist Production Enterprise" to economically independent computing subdivisions. And that is exactly what our road computing centers are.

Of course, it also takes time to apply this "statute" to our computing centers. The development of methodological instructions was begun just a short time ago in the USSR Central Statistical Administration and Gosstat, the departmental pioneers in the question of the economic independence of computing subdivisions. They are the ones, I feel, from whom we should take our example in this matter. All the Central Statistical Administration computing centers, for example, constructed their relations with customers on principles of economic accountability almost immediately after being launched.

In analyzing the material published in GUDOK we may notice a number of patterns. Employees of the section and road divisions of statistical accounting and reporting are determined not to find themselves in a secondary role. At the same time, they welcome any lightening of their workload, if the computing center can really do it.

For their part, the managers of the computing centers, being dependent on the receipt of information (and to a significant degree it comes from the divisions of accounting themselves!), are still unenthusiastic about proposals to switch their collectives to economic accountability. What is the matter?

Economic accountability means obligations. Economic independence helps identify those who work better and worse, those who have initiative and those who do not. This may explain a certain inertia with respect to economic accountability principles seen in both the authors who have participated in the debate and in the Main Administration of Computer

Technology itself (however, often this inertia is completely natural to our financial experts).

In any case, all the arguments presented by them are, in my opinion forced. Almost any enterprise that is economically sound today can point to numerous factors which prevent it from working more efficiently. But no one in this case would even think of renouncing economic accountability principles.

Therefore the view of the Scientific-Technical Council of the Ministry of Railroads on this issue is clear and definite: the computing centers of the roads should be switched to economic accountability. We hope that the main administration of computer technology and the financial people will find an acceptable solution to the problem in the near future.

But this alone, I think, is still not enough to sharply improve the efficiency of computing center work. Whether we want to or not, the time has come to turn over to machines all the data functions they can handle. And to see that this potential is broadened quickly, from my point of view the time has come to consolidate the divisions of statistical accounting and reporting themselves with the computing centers. In that case at least the "double bookkeeping" written about in GUDOK will no longer occur.

If we take this further, there is no doubt that the Transorgmashuchet [State Trust for the Organization of Machine Accounting of the USSR Ministry of Railroads] should be joined to the Main Administration of Computer Technology and its machine accounting factories consolidated with the appropriate computing centers as structural units. In this way, the existing machine accounting stations will become the basis of future information and computing centers on the sections, while today they can supply raw data to the computing centers. I realize that financial experts oppose this step at the present time. But their reason is only that the machine accounting factories in large part work for the financial divisions and services and are handling a basically narrow matter, the mechanization of bookkeeping.

It seems to me that we should think not on the basis of what these factories are doing today, but rather what they should and can do. Left under the direction of the financial people the factories will never become a basis for primary processing and delivery of data to computing centers. But if they are joined with the computing centers they will not be able to refuse the work which they do today on orders from the financial specialists. This is because, in the first place, bookkeeping is a constituent part of the automated control system for railroad transportation. Any curtailment of calculations on this level will deprive them of an important source of raw data for accomplishing other tasks. In the second place, economic accountability means economic accountability and it is inconceivable without output. Performance of the order is the output of the machine accounting factory. The situation today when they are subordinate to

financial divisions is no different from what it would be in the future if they were subordinate to computing centers. From this it follows that transferring the machine accounting factories to the computing centers is an expedient and timely step.

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ORGANIZATION OF THE NETWORK OF COMPUTER CENTERS IN THE ESTONIAN SSR

Tallin IZVESTIYA AKADEMII NAUK ESTONSKOY SSR. FIZIKA MATEMATIKA in Russian Vol 26 No 2 1977 pp 225-228

[Article by Yu. Liyyak, Institute of Cybernetics, Estonian SSR Academy of Sciences]

[Text] The basic purpose of the Republic Automated Control System (RASU) is to improve the planning and control of the national economy and the social life of the republic on the basis of the extensive use of mathematical economics methods and computer technology and communication facilities. In order to achieve this goal, it is first of all necessary to insure the high quality of the information circulating in the RASU through the proper use of computer software. If providing high-quality data at minimum cost is adopted as the criterion of functional efficiency [1], then the Republic Network of Computer Centers (RSVTs) should have the greatest effect on the formulation of the structure of the Estonian SSR's RASU.

In this article we define the requirements for the RSVTs and discuss its structure and topology.

Requirements for the RSVTs

A computer network is a set of computer centers and subscriber points, which elements are connected by a data transmission subnetwork that gives the consumers the capability of transmitting, processing and storing data under resource-separation conditions.

An efficiently functioning RSVTs must satisfy the following requirements:

1. Provide the necessary data quality (reliability, response time, confidentiality);
2. Have the appropriate resources for processing the given volumes of data and satisfying diversified consumer requests.

3. Be flexible, reliable, and capable of further development.
4. Be economically efficient; that is, the cost of processing data in the computer network must not exceed the cost of doing it with independent computers.

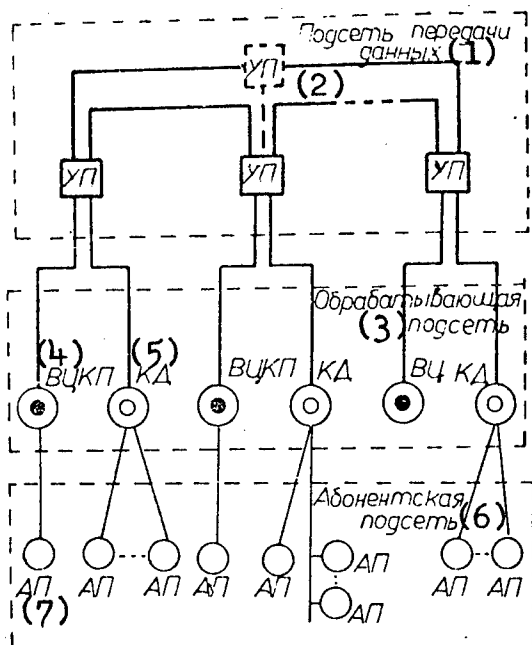


Figure 1. Structure of the Estonian SSR's VTs network.
Key:

1. Data transmission sub-network
2. Junction processor
3. Processing subnetwork
4. Collective use BTs
5. Data concentrator
6. Subscriber subnetwork
7. Subscriber point

presence of which will:
increase the reliability and operational efficiency of the VTs network because of the use of monotypical and compatible equipment in the PPD;
increase the network's flexibility, viability, and capacity for further development;
free the information- and data-processing computers from the network control function; that is, make it possible to clearly separate the processing functions from the data transmission functions [1].

Despite the significant expenditures involved, the creation of computer networks fulfills the last requirement in full measure, since it makes it possible to eliminate excessive resources and use the already existing ones more efficiently. Besides this, it is possible to achieve an additional economic savings by concentrating large computational capacities in several VTs's [computer center] during the organization of the computer network, because in the final account this results in a reduction in the cost of processing data.

Structure of the RSVTs

In view of the fact that in the near future we will see the appearance of specialized junction processors (UP) based on mini- or microcomputers, it has been proposed that UP's be used in the switching junctions of the TSVTs's primary structure [2]. The use of UP's will make it possible to form an independent data transmission sub-network (PPD) in the RSVTs, the

An analysis of the information flows showed that half of the total volume of processed data, as well as the network's equipment and programming resources, can be concentrated in one place. Therefore, it makes sense to set up an independent PPD in Tallin and to connect the regional centers with the help of a regional data transmission subnetwork.

Thus, the RSVTs's structure should contain (Figure 1): two interconnected PPD's -- one in Tallin and a regional PPD consisting of UP's that are interconnected by high-speed data transmission channels; VTs's that are connected to the PPD's with the help of medium- or high-speed data transmission channels; subscriber points (AP) that are connected to the collective use computer centers (VTs KP) and the PPD's, with the help of data concentrators (KD), through low- or medium-speed data transmission channels.

Selecting the Topology of the RSVTs's PPD

A network that is correctly planned from the topological point of view is a vital, reliable network that creates potential capabilities for the efficient control of data flows.

In worldwide practice, computer networks are created with the use of both centralized (the "star" type) and decentralized networks. The latter includes ring-shaped and distributed, incompletely connected networks.

Of these different kinds of networks, the "star" type is the least reliable, because there is a catastrophic failure of the entire network whenever the central controlling computer breaks down. As the controlling computer in such a network, therefore, either paired computers or a computer complex is used, which increases the network's cost and complexity. Centralized networks are also inferior to other types (such as ring-shaped ones) as far as the length of their communications channels is concerned. The advantage of centralized networks is the ease with which the data flows are controlled.

From the viewpoint of control, distributed networks are the most complex ones, but at the same time they are unequalled for reliability and productivity.

"Ring"-type networks are worthy of the most serious attention [1]. These networks surpass centralized ones in reliability and are their equal in simplicity of the control process. However, it is true that they are inferior to distributed networks in productivity and reliability when the data transmission channels' traffic capacity is the same. This shortcoming can

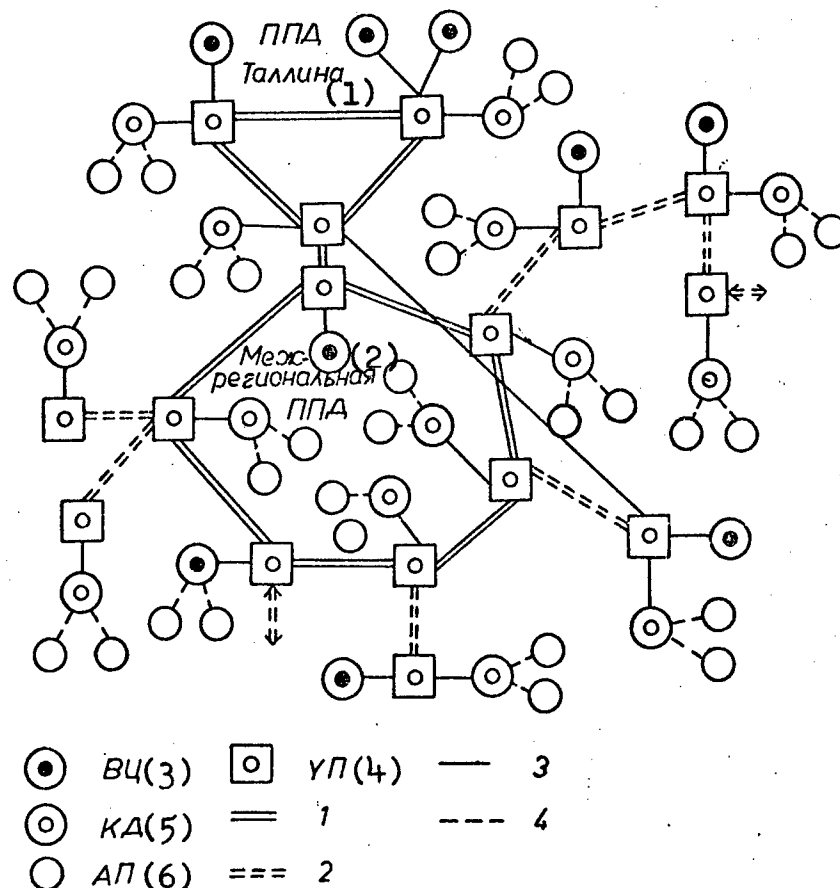


Figure 2. Topological structure of Estonian SSR's VTs network. Separate high-speed data transmission channels: 1. main; 2 radial. Switchable and separate data transmission channels: 3. medium-speed; 4. low-speed.

Key:

- | | |
|----------------------|-----------------------|
| 1. Tallin PPD | 4. Junction processor |
| 2. Interregional PPD | 5. Data concentrator |
| 3. Computer center | 6. Subscriber point |

be eliminated by using duplex transmission (the presence of which eliminates catastrophic breakdowns) or by adding throughput keys and reserve switchable channels with medium traffic capacity to the junction equipment. Moreover, these networks are comparatively cheap.

Keeping in mind all the advantages of ring-shaped computer networks that were enumerated above, we consider it advisable that the initial RSVTs complex (which is the VTs network in Tallin) be begun with a ring-type topology and that it be subsequently expanded into a distributed network.

For the interregional PPD it makes sense to recommend the ring-shaped topology, with the regional and rayon centers with the greatest density of processed data that are not encompassed by the ring being connected to the PPD with the help of radial channels.

The proposed topological structure of the RSVTs is shown in Figure 2.

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USING EXISTING TESTS IN MONITORING HOLOGRAPHIC STORAGE DEVICES

Frunze IZVESTIYA AKADEMII NAUK KIRGIZSKOY SSR in Russian No 5, 1977 pp 35-38

[Article by R. T. Seydakhmatova, Moscow Power Institute]

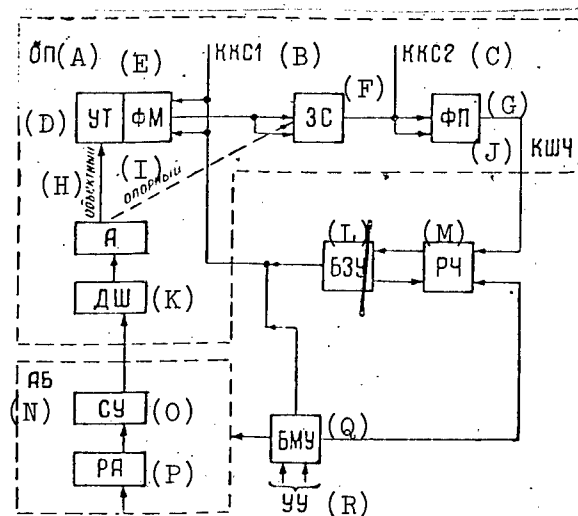
[Text] Each stage in designing storage devices is characterized by certain monitoring methods: 1) checking of components used in device assemblies; 2) checking of matrixes or assemblies of storage device; and 3) checking the storage device as a whole, at the level of systems. In the first two stages, generally the quality of functioning of components and assemblies is checked with stands, that is, a check is made for correspondence with given characteristics and often, functional monitoring. Analyzed in this study are the conditions that have to be imposed on the tests employed in functional monitoring of operational holographic storage devices (GOZU [golograficheskiye operativnyye zapominayushchiye ustroystva]).

Functional monitoring is very important at the third stage, at the stage of integrated check-out of GOZU, since it affords a check-out in several more complicated conditions typified by the operational specifics of the storage device under normal check-out conditions in the stable operating region. Conditions under which these tests function are determined by the characteristics and properties of the GOZU assemblies checked and are intended for organizing the worst operating conditions of the storage device that ensure the detection of interference distorting GOZU performance.

Finding the specific features of tests used in monitoring GOZU performance required analyzing the transient and stationary processes happening in GOZU and seeing whether it is possible to turn to existing tests or their modifications in monitoring. Ordinarily, static and dynamic tests are used in checking out storage devices. Dynamic tests, by and large, serve in evaluating the effect of transient processes occurring in the data bus, in the region of stable operation of the memory module. Their function is detecting interference from the interaction between adjacent memory cells, from the order of shift in distributions, from the rate of cell access and other factors. Dynamic processes can also serve in evaluating transient processes in address buses of the memory device. Statistical tests are generally marked by constancy of data in cells during the test.

Let us find where the address and data connections of GOZU run. To do so, let us indicate the main blocks of the GOZU and the circuits connecting them (see Figure).

A typical feature of GOZU block diagrams is the absence of electrical connection circuits, that is, the wires between DSh and UT, ZS and FP, UT and ZS. They appear between FP and RCh, RCh and BZU, BZU and UT. Their minor length notwithstanding, they can be classified with data channels and denoted by KShCh, KKS1, and between FP and ZS--by KKS2, in spite of the absence of wires... The minor length of address and data wires of connection reduces the effect of transient processes in the wires on the recorded data entered therein. Then by transient processes in the address channel we mean processes occurring in assemblies such as the DSh, in connection wires between SU and DSh, and also in SU parts.



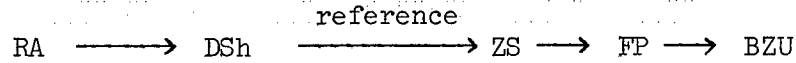
Block diagram of GOZU

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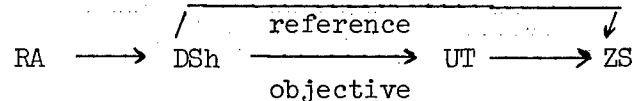
- | | |
|--------------------------------|-------------------------------|
| A. OP | J. KShCh, number coding bus |
| B. KKS1, page coding channel 1 | K. DSh, decoder |
| C. KKS2, page coding channel 2 | L. BZU, buffer storage device |
| D. UT, controlled transparency | M. RCh, number register |
| E. FM, phase mask | N. AB |
| F. ZS, storage medium | O. SU, coder control circuit |
| G. FP, photocells | P. RA, address register |
| H. Objective | Q. BMU, local control block |
| I. Reference | R. UU, control device |

Transient processes in the data channels KKS1 and KKS2 will be caused by transient processes in UT and FP. So the GOZU is characterized by the presence of three main data channels (KKS1, KKS2 and KShCh) and the address channel KKA. Operation of the GOZU can conditionally be depicted as follows:

In counting:



In entering:



A is a system of lenses, UT, ZS and FP make up the optical part of the storage device (OP); DSh, operating on an optical principle, also is part of the OP; RA and SU constitute the address block of the GOZU; BZU is an intermediate ZU between the GOZU and the remaining computer assemblies; BMU is a block synchronizing the operation of all GOZU blocks. Therefore, the main GOZU blocks are these: AB (address block), OP, BZU and BMU.

One structural feature of the GOZU is the inclusion of a phase mask (FM) and use of an out-of-phase method of coding data fed into the UT. The out-of-phase method of coding preserves the given intensity of the light flux arriving at one photocell of the FP matrix. The FM more uniformly distributes data at the surface of the ZS.

Thus the features of test monitoring of the GOZU are these:

1. In the GOZU data are entered by pages (holograms). The main feature of data entered on the ZS is the characteristic of the properties of the data entered in terms of the value of the mean intensity of the recorded light, and not the intensity corresponding to each information bit. The mean intensity is determined by the total number of bits in the hologram. Then the total value of interferences caused by each information bit for the whole ensemble of bits on the page can be expressed in terms of the root-mean-square fluctuations in intensity in the hologram plane. The mean intensity of the light waves is determined by the intensity from a single opening magnified N times, where N is the number of openings in the UT [1]. The mean size of the hologram is determined by the parameter of the central spot--an Airy disk, and the information characteristics of the pages--by the frequency ξ of the location of the interference bands in the disk. Use of the FM and the constancy of the location of openings in the UT allow us to say that ξ is more or less constant for any change in information in the UT. Interference in the operating conditions of the GOZU caused by the information content of the pages will amount to diffraction rings encircling the Airy disks and the fluctuations in intensity caused by errors in the phase sampling of the pages. So the very process of entering the page in the GOZU corresponds to inserting data in individual memory cells, for example, a ferrite memory, therefore for each hologram will designate a page, as the memory cell.

2. Constancy of information in given pages (cells) is determined by the operating specifics of the GOZU--a direct method of entering and selecting information.
3. Dynamic processes in the GOZU are determined by the algorithm for sorting through pages in the tests.
4. Based on feature one, it follows that all that is needed in checking that GOZU assemblies are working properly is unit or zero information on the pages.
5. Errors growing out of the drift of GOZU parameters can be found from the site of localization of malfunctions on the page. Malfunctions from page interaction are concentrated in the margins of the pages and malfunctions from drift in intensity, for example, because the DSh and media are heated, are concentrated over the entire page surface.
6. A feature of the tests serving in checking the FP and UT matrixes is that there is no need for identifying the malfunction down to the level of individual parts of the FP and UT. In this case, all that is needed is a sign that there is a malfunction on the page. Repair then takes place without its replacement.

Features two and three show that there is the possibility of using the algorithms of the dynamic tests "Rain" and "running unit" for monitoring the GOZU, but feature one indicates the redundancy of the "Rain" test. Based on the foregoing and the study [2]--establishing the conditions determining the sorting of tests monitoring the performance of the address block of the GOZU, the following dynamic tests operating in the automatic mode can be proposed for monitoring the operation of the GOZU address block:

T1 (test 1) is sorting of the pages along the diagonal (in this case, a check is made on the basis of the drift in the DSh rate as a function of the address) with unit information entered on the page

T2 is the sorting of pages in sequence with the entering on the page of only unit information (a check is made for drift of the frequency of the acoustic wave-deflector)

T3 is the sorting of pages along the diagonal or in sequence; onto the sorted pages unit and zero information is entered alternately; in this case malfunctions caused by the interaction of pages one on the other are more distinctly uncovered

T4 is the organization of the algorithm of access to the GOZU by the "running pages" method, for pages that carry unit information, against a background of pages with zero information, or vice versa. The effect of media on the monitoring of the DSh is reduced to a minimum by monitoring operations after completion of information recording on the pages

T5 is the dynamic range of tests monitoring media and consists of organizing of the modes of multiple access to a page filled with unit or zero information. The effect of address buses on the test performance reduces to a minimum by insertion of certain intervals during which no GOZU access takes place, or by switching to patches whose addresses correspond to the smaller values of frequencies controlled by DSh operation.

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CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

MINISTER OF INSTRUMENT-MAKING REPORTS' ON INDUSTRY PROGRESS

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 10, 1977 pp 1-2

[Article by K.N. Rudnev, USSR minister of instrument making, automation equipment and control systems: "The Instrument Making Industry by the Anniversary of the Great October Revolution"]

[Text] Fulfilling the resolutions of the 25th CPSU Congress, instrument makers in the second year of the 10th Five-Year Plan are reporting to their homeland on their achievements in their work, in advances in technological progress, and in the socialist competition, which has unfurled with renewed strength in all collectives of the industry on the eve of the anniversary of the Great October Revolution. Just as in previous years, at instrument making enterprises labor productivity has grown at a high rate, product output has increased, new technics have been mastered, and a significant proportion of these technics are designed to automate leading industries in the national economy. The self-sacrificing labor of our workers, engineers, and scientists has borne visible fruit. The profound high-quality advanced changes over the last 10 years in the structure of production processes and in the technological level and systematization of production are the result of this labor.

As we know, during 1967-1977 foremost advances were made in computer hardware, the output of which increased more than tenfold. This consisted of control computer complexes for controlling processing units and production processes and for automating planning, keyboard computers for economic planning estimates, billing and bookkeeping machines, and a series of computer complexes for automating scientific experimentation and for controlling the quality of various industrial products. The production of key types of electronic hardware and numerical program control equipment for machine tools has been converted to a microelectronic component base which is being steadily improved. At the present time a transition is under way to large-scale integrated circuits and microprocessors.

In the current five-year plan period development has been completed and production has been begun on equipment for a system of small computers (SM series computers) standardized for the socialist countries, which in conjunction with YeS computers makes it possible to satisfy the demand for computer hardware of the national economies of sister countries.

By 1977 the list of equipment for numerical program control of machine tools was replaced completely. The special-purpose N-22-1, N-33-1, and P-32-3M equipment for controlling turning, milling, and boring machines produced at the present time is at the state of the art.

A new factor in the industry's development has been the formation and rapid advance of subindustries devoted to developing and putting into operation automated control systems (ASU's). More than 3000 ASU's for manufacturing processes, enterprises, and sectors of the national economy have been put into operation, including 80 control systems at instrument making enterprises.

The technological level of ASU's for manufacturing processes and of industrial ASU's has been raised substantially. Systems have been created which are based on modern scientific structural and functioning principles (direct digital control systems, adaptive and integrated systems). For example, the adaptive system for controlling a tube-rolling mill introduced at the Ural'sk New Tube Plant makes it possible to change the mill's operating mode to adapt to the characteristics of the stock entering to be rolled. The creators of this system were awarded the USSR State Prize for 1976.

In the area of new automation equipment the industry has shifted for the time being to developing and putting into operation chiefly combinations of standard units and unified instrument systems. This is making it possible to satisfy fully the demand of the national economy for instrument making products and to achieve high production efficiency through extensive introduction of unification and standardization.

For the first time in worldwide instrument making practice a State system of industrial instruments and automation equipment (the GSP) has been created to fulfill the needs of automating practically all branches of industry with continuous and continuous-and-discontinuous types of production processes. Arranging for the industrial manufacture of efficiently designed series of instruments which are technically compatible with one another has made it possible to design and apply highly diversified and complex systems for monitoring, regulating, and controlling. Constant work is being done on expanding the list of measurable parameters and measurement ranges and on improving the metrological characteristics and performance ratings of instruments. Special attention is being devoted to creating measuring equipment which is capable of operating under severe production and climatic conditions, including in highly corrosive environments, under heavy overloads and vibration, and in high radiation. Now enterprises of the industry are mass producing more than 2000 different types of GSP products, forming scores of different functional and parametric banks taking care of practically all key problems in measuring, monitoring, and regulation in systems for automating leading industries in the national economy.

The manufacture of a combination of efficient instruments for scientific research has been arranged for: electron microscopes, mass and radio spectrometers, instruments for x-ray crystallography and x-ray spectrum

analysis, chromatographs and gas analyzers. Work has been begun on creating equipment which will assist in protecting the environment.

High-quality changes have taken place in overall outfitting of a number of leading branches of industry with instrumentation. As a result of working out, in conjunction with these industries, long-term plans for automating and metrologically outfitting production processes, an extensive list of instruments and automation equipment has been created for power engineering, ferrous metallurgy, the oil and gas industry, the building materials industry, and other industries. As examples of subjects of overall outfitting can be named blasting, converter, and rolling processes in ferrous metallurgy, high-capacity boiler-turbine-and-generator plants in power engineering, and oil production enterprises.

Mention should be made of the total reoutfitting of enterprises manufacturing consumer goods. The list of these goods is being renewed steadily and at the present time it numbers about 18,000 articles. The assortment has been changed completely and the reliability and accuracy of home timepieces have been increased. The manufacture of electronic and electromechanical timepieces has been arranged for.

The technological level of all of the industry's products has been raised considerably. The reliability of computer hardware, instruments, and automation equipment has increased to a great extent. The metrological ratings of instrument making products have improved. The industry's products are being manufactured in total conformity with the high specifications of State standards and are conforming with the specifications for products of the top- and first-quality categories. In 1977 the industry's enterprises have put out more than 1200 different types of products with the State Emblem of Quality, representing a total of about 730 million rubles worth. The competitiveness of instrument making products on the foreign market has increased. Many products have received high esteem at international exhibitions and are being exported to various countries.

The rapid rate of growth of instrument making production is helping to solve successfully one of our major national economic problems--the problem of automating production and control processes in key branches of industry for the purpose of increasing production efficiency and improving product quality.

The socialist obligations of instrument makers assumed in honor of the 60th anniversary of the Great October Revolution have been fulfilled. Many patriotic undertakings were born in the course of the competition and received wide support. The motto "Efficiency, Quality, and Economy at Each Work Place" became law for scores of thousands of instrument making enterprise workers. The leading teams of the Vil'nyus Sigma PO [Production Association], the Chelyabinsk Teplopribor Plant, the Moscow Manometr and Second Timepiece plants, the Kiev Tochelektropribor PO, and many others, in keeping with the established tradition of meeting important dates with new achievements in work, are reporting on their successes to the homeland with honor.

A worthy contribution to advances in domestic science has been made by personnel of the industry's scientific research and design organizations. Scientists, engineers, and workers at the Institute of Control Problems, the Leningrad Burevestnik NPO [Scientific Production Association], the Institute of Electronic Control Computers, the NIITEPLOPRIBOR [Scientific Research Institute of High-Temperature Instrumentation], VNIPI OASU [All-Union Scientific Research and Production Institute of Industrial Automated Control Systems], and other leading organizations of the industry have reached the holiday of the Great October Revolution with great achievements in creating and mastering new equipment which is on the level of the best models in the world.

The 60th Anniversary of the Great October Socialist Revolution has become for teams of the instrument making industry a powerful stimulus toward performing vital work and toward ingenuity-laden enthusiasm aimed at increasing to the utmost production efficiency and work quality and at successful solution of the problems presented by the 25th CPSU Congress.

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CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

ASU TP DEVELOPMENT TRENDS TRACED, FORECAST

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 10, 1977 pp 17-19

[Article by A.A. Levin, candidate in technical sciences and chief engineer of the Soyuzpromavtomatika VO [All-Union Association]: "Modern Trends in Creation of ASU TP's [automated systems for controlling technological processes] for Processes of a Continuous or Continuous-Discontinuous Nature"]

[Text] During 1973-1976 the development of work on ASU TP's received powerful "accelerating momentum." This consisted first and foremost in creating and putting into operation large-lot production of third-generation control computer complexes (UVK's), in holding the special "ASU TP - 74" international exhibition, and in solving a number of fundamental problems relating to the strategy of developing this trend in technology by special decree of the USSR Council of Ministers with regard to making advances in work on creating automated systems for controlling technological processes, units of standard equipment, and production processes in industry.

The CPSU Central Committee devoted a great deal of attention during this period to expanding work on ASU TP's. General questions and procedures for carrying out the majority of specific measures relating to creating and introducing ASU TP's concern mostly five fundamental aspects: scope and volume of work, engineering policy for carrying it out, economic indicators, scientific and technological methods, and hardware provision.

Scope and Volume of Work

The results of the Ninth Five-Year Plan for developing the national economy and plan quotas for the 10th Five-Year Plan make it possible to compare indicators which objectively typify the dynamics of advances in automation of control in key branches of industry with continuous and continuous-discontinuous types of production. These indicators are, in particular, the ratio (as a percentage) of expenditures for automation to the total amount of the industry's capital investment, and the absolute values of figures for these expenditures.

As early as in the Ninth Five-Year Plan the first quotas (1973) for forecasting advances in work on automating control for 1971-1990 showed a

noticeable increase in the proportion of expenditures for automation in all branches of heavy industry. Meanwhile nothing of the sort took place in practice. The increase in this figure in quotas for the 10th Five-Year Plan also turned out to be substantially more modest.

The actual total expenditures for automation in the Ninth Five-Year Plan for the power engineering, oil and gas, oil refining, chemicals, and paper and cellulose industries, ferrous and non-ferrous metallurgy, and the building materials industry turned out to be approximately 14 percent below the forecasted figures.

Since total capital investment in heavy industry in the 10th Five-Year Plan is somewhat lower than expected in the 1973 forecast, accordingly expenditures for automation will be approximately 36 percent lower than indicated, but their absolute value, however, as compared with expenditures for automation in the Ninth Five-Year Plan, will increase by more than a factor of 1.8.

Comparing actual development data with forecast data not only characterizes the quotas of the 10th Five-Year Plan in close-up, but also emphasizes the importance of the work which is being done to fulfill the quota of the abovementioned decree of the USSR Council of Ministers for development of advanced standards for specific expenditures for automation.

Experience has shown that without doing this work it is difficult to ensure on-schedule scientific and technological development within the necessary limits and proportions. This is especially important since practice has demonstrated that simple comparison of domestic data with statistical data from the USA cannot be used in planning estimates, since allowance is not made for the difference in pricing relationships and methods of attributing expenditures.

During the years of the Ninth Five-Year Plan 180 ASU TP's based on third-generation UVK's (this is the key reporting unit in the 10th Five-Year Plan) were put into operation, and of these 113 systems were put into operation in different branches of industry with the participation of organizations of the Soyuzpromavtomatika VO.

In the 10th Five-Year Plan introduction of ASU TP's based on UVK's is planned for branches of heavy industry (51 percent of the total number of these systems to be put into operation in the national economy), for machine building industries (34 percent), and for enterprises of the other Union and republic ministries and departments (15 percent). From this data characterizing the quotas of the 10th Five-Year Plan in the area of creating and introducing ASU TP's two conclusions can be drawn.

1. The ratios which have been arrived at for putting ASU TP's into operation are not random. It has been proven that without the necessary preparatory stage and the stages of putting prototypes into operation and accumulating

scientific and practical know-how in a specific industry it is impossible to launch wide-scale introduction of ASU TP's in an amount whereby the results from putting them into operation will begin to be reflected noticeably in technical and economic indicators on the industry-wide scale.

2. The volume of introduction of ASU TP's with third-generation UVK's has increased by a large factor in the 10th Five-Year Plan.

Engineering Policy

To evaluate the know-how gained in questions of engineering policy, it is sufficient to compare the fundamentals of this policy with the results of its practical implementation.

In the Ninth Five-Year Plan in selecting sites for creating ASU TP's priority was given to new, large-scale, and long-term technological processes, units of standard equipment, and production processes. Practice has fully confirmed the correctness of this principle. In spite of specific difficulties in designing systems for new sites, the effort spent on creating ASU TP's at precisely these sites (blast furnace No 9 at the Krivorozhstal' Plant imeni Lenin, the "Polimir-50," the general-purpose beam-rolling mill, and other new controllable processes) turned out to be most "systems-efficient," overall effective, efficient, and conducive to progress. This principle has been approved as an organizational basis for the immediate future.

In the Ninth Five-Year Plan the work of organizations of the Soyuzprom-avtomatika VO was oriented toward a harmonious combination of ASU developments ranging over the entire hierarchy of modern manufacturing: from the unit to the enterprise. Furthermore special attention was devoted to the most complex and crucial level of control--to direct control of technological production processes. Experience has shown that this policy makes it possible to achieve the best results and is essentially the only promising policy from the science and technology viewpoint.

Not to automate units designed for manual control, but to create automated units and technological processes--the correctness of this fundamental position of engineering policy has been proven beyond dispute by facts. But implementation of this aim has proven to be a quite difficult matter. Successful completion of developments of this sort, as has been shown, is in the power of only individual very highly trained teams and even of only experienced and authoritative leaders. Experience has proven that for successful fulfillment of this work it is necessary to pay special attention to its organization for the purpose of concentrating considerable resources on it from the very start.

Engineering policy with regard to furnishing ASU TP's with control computer hardware has been aimed at, along with increasing the production volume of the series of standard M-6000 models, overcoming all major design and program difficulties associated with setting up deliveries of so-called "special-purpose" complexes. It has been confirmed by practice that this was

the only realistic policy. It has made it possible as early as in 1977 to put out somewhat more UVK's than for the entire Ninth Five-Year Plan and to furnish a number of the most important ASU TP's with unique special-purpose UVK's.

Thus, in the area of engineering policy practical experience of recent years has not only not made necessary any revision of its foundations but on the contrary has confirmed their effectiveness and forward-looking nature.

Economic Indicators

In 1976 organizations of Minpribor [Ministry of Instrument Making, Automation Equipment, and Control Systems] made a study of the effectiveness of a number of earlier introduced ASU TP's. Summarization of the results of this study has made it possible to reveal some important patterns.

For many years the high efficiency of local control systems was regarded as axiomatic. In the last five-year plan period this "usual" attitude was extended almost automatically to so-called "ASU's utilizing computer technology."* Furthermore in a number of instances it was assumed without proof that the higher the "caliber" of the computer technology used, the more modest the annual savings.

Experience has demonstrated that these attitudes have already become out-moded and can in a number of instances result in an erroneous viewpoint. Analysis of the efficiency of 455 systems introduced during the period of 1971-1975 through developments of the Soyuzpromavtomatika VO has confirmed that the mean annual savings per system utilizing computer technology amounted to 251,000 rubles, and for 113 ASU TP's out of this number based on mass-produced UVK's the mean annual savings amounted to 657,000 rubles. Regardless of the accuracy of the absolute values of these figures their relationship indicates the necessity of a new approach to estimates of this sort.

Judging from the results of this study, on the whole the pay-off periods for capital investment, even for creating prototypes (with these there are substantially increased expenditures for developing new equipment, "idle periods," remodeling, and the like), are considerably less in key branches of heavy industry than standard industrial pay-off periods. For example, in power engineering ASU TP's are paid off in 2.4 to 4.5 years versus a normal eight years, in the oil producing industry in 0.8 to 2.5 years versus a normal five years, in ferrous metallurgy in 0.4 to 2.5 years versus a normal eight years, and in non-ferrous metallurgy in 1.2 to 2.8 years versus a normal five years.

*By this term is understood the use of quite diversified computer hardware: from the simplest electronic automatic logic devices to multicomputer UVK's.

At the same time experience has demonstrated that the preplanning estimate of efficiency (especially for existing controllable processes) should be made exceedingly responsibly and according to principles.

The economic efficiency and pay-off periods for ASU TP's depend directly on the amount of expenditures for creating the systems. Analysis of such expenditures for a number of systems with UVK's introduced in full or part during 1971-1975 has made it possible to make a precise determination of the actual relationships between developing and introducing ASU TP's in terms of key components.

For the period under consideration the use of UVK's was most characteristic, of course, in automating control of processes of classes three to six (in keeping with Minpribor's classification system), i.e., units of average and high output and processing lines and shops with single- or two-level control structures.*

The allocation of actual (average) expenditures for creating ASU TP's with UVK's in 1971-1976 is shown in the following table.

Items of expenditure	Expenditures in % for ASU TP classes			
	3	4	5	6
NIR [scientific research operations] and OKR [systematization and design operations]	23	14	52	42
Planning operations	13	5	5	4
Assembly and debugging	13	21	5	9
Instruments and automation equipment	51	60	38	45

This data makes it possible in particular to estimate the feasibility of further increasing the efficiency of ASU's being developed by reducing expenditures for creating them and first and foremost expenditures for carrying out NIR and OKP and acquiring equipment facilities.

We know that as of 1 Jan 76 there has been a considerable reduction in prices for third-generation UVK's. A further lowering of prices for UVK's can be expected with the transition to small SM series computers.

Expenditures for NIR and OKR can also be reduced by circulating systems, creating libraries of algorithms and application programs, and by maximum development of prototypes under proving ground conditions at scientific experimentation centers. Thus there is an actual possibility of reducing by approximately 1.5 times more the pay-off periods achieved for ASU TP's in the Ninth Five-Year Plan.

*A.A. Levin, Yu.S. Val'denberg, et al., "Classification of Automated Systems for Controlling Technological and Production Processes," PRIBORY I SISTEMY UPRAVLENIYA, No 4, 1970.

Scientific and Technological Methods

Analysis of the results of work carried out and an estimate of the prospects for developing it makes it possible to single out the following eight principles or methods for modern design of ASU TP's: 1) control using a "quasi-steady-state" one-time model; 2) control with a standard model of the controlled process (including one to be used for calculations in accelerated time); 3) adaptive control (including with an identifier); 4) direct digital control (NTsU); 5) control with active monitoring of parameters of the technological process; 6) remote automatic control; 7) control with a partly decentralized processor structure (a ChD ASU); and 8) integrated control.

An evaluation of the frequency of implementation of these principles in specific ASU's considered and created in 1971-1976 revealed certain general trends in their development in the future.

1. Control utilizing a quasi-steady-state one-time model of the controlled process was implemented in approximately 40 percent of ASU's, i.e., this method received considerable development and will probably find application in the immediate future.
2. Control with a standard model of the controlled process used for calculations in accelerated time was implemented in only three systems. Application of this method requires the presence of an easily augmented internal storage (up to 64K words) and an intense study of a complicated process. These conditions are evidently the cause of relatively slight implementation of this method. It can be expected that in the current five-year plan period the number of systems using this method will increase by a factor of three to four.
3. The principle of adaptive control was implemented in full in approximately seven ASU TP's and should become one of the most important principles in the further development of control automation.

In extractive and key processing branches of industry continuous and continuous-discontinuous production processes are chiefly of a fundamentally indeterminate and non-steady-state nature. As far as these processes are concerned the application of adaptive methods seems not only reasonable, but in a number of instances the only effective one. Taking these circumstances into account in the presence of an advanced domestic theoretical school and numerous highly qualified specialists makes it possible to hope that not less than 60 ASU TP's applying the principle of adaptation will be implemented in the current five-year plan period.

Direct digital control was implemented in only 14 systems. Among the number of possible reasons for the small number of systems with NTsU are insufficient outfitting of systems with equipment and a drawn-out solution, in terms of time, to the question of replacement of what number of individual controls makes multichannel digital control economically justified. Because of

an orientation toward the "ruble equivalent" of this replacement the feasibility of obtaining fundamentally higher-quality control was underrated.

At the present time the main reasons for lagging behind have been eliminated and it should be expected that in the current five-year plan period not less than 80 to 90 ASU TP's will implement NTsU methods.

5. Total implementation of control with active monitoring of parameters of the technological process or product was absent in the systems dealt with.

The use of UVK's for correcting values of parameters measured, resetting the monitoring mode, correlation filtering, automatic entry of corrections, and the like makes it possible in a number of very complex metrological situations to increase the accuracy of control by approximately an order of magnitude, as compared with using classical sensors and multiloop analog monitoring. The appearance of a certain number of these systems should be expected in the 10th Five-Year Plan.

6. Automatic remote control was implemented in seven systems. The objective cause holding back proper development of this trend was the absence of mass-produced remote control equipment compatible with computers from the hardware and software standpoints. With mastery of industrial manufacture of remote control equipment of the TM-301, TM-310, TM-120, and TM-260 types this cause has been eliminated, and in the current five-year plan it should be expected that about 60 systems will be put into operation utilizing automatic remote control methods.

7. By control with a partially decentralized processor structure is implied control utilizing microprocessor technology. As yet no systems exist which have been created with application of this principle. But we know that the last 15 to 20 months all the largest foreign firms in the field of industrial automation have set into action work on utilizing this new technological achievement in ASU TP's. It can be assumed that application of microprocessor units will evoke changes in industrial automation no smaller and possibly even greater than the appearance of semiconductor logic. Microprocessor technology removes practically all economic and production limitations and increases the life and repairability of ASU "intellectual hardware."

8. Integrated control, worked out in the form of trial "particular" solutions, has been implemented for only six controlled processes. To the present time the essence of the principal difference between the sum of an ASU TP and ASUP and an integrated system has remained unclear. Development of a method of integrated control requires carrying out studies on the scientific and systems level. Nevertheless in the current five-year plan period it should be expected that a number of integrated systems will be created at the level of individual production processes, technological networks, and enterprises.

Some Questions Relating to Providing Hardware

At each stage of development of the problem of "Systems and Hardware" specific aspects of the problem can be singled out.

In the recent past it was a shortage of UVK's for ASU TP's. At the present the center of gravity of the problem has shifted to the quality characteristics of UVK's. It is obvious that the demand for computer hardware for creating ASU TP's will be satisfied completely in the immediate future.

One of the tasks of ASU development organizations is the duty of timely filing of requisitions for outfitting special-purpose UVK's. With the transition to SM series computers, distinguished by greater unification of design, work on outfitting and transforming UVK's will be facilitated. Nevertheless, in the course of the 10th Five-Year Plan the shortage of peripherals for SM series computer UVK's will dictate the necessity of rapidly determining the structure of each special-purpose UVK.

Recently a new essential contradiction has arisen in the "Systems and Hardware" problem. "Make and deliver ASU TP's" is an expression used in departmental documents of different levels (in correspondence of organizations and even in drafts of resolutions of State administrative agencies). It would seem that the incorrectness of this word combination is obvious. Each specialist in the field of control automation understands that an ASU TP "begins" when, and only when, the totality of hardware has been installed at the site, it has been connected for interfunctioning, and has been absolutely "animated" with the appropriate directions for interaction between hardware and between hardware and the controlled process. Therefore, it is impossible to "deliver an ASU." Why then is this formula so persistent, when it results in a false understanding of the essential nature and makeup of operations and concentrates attention only on the job of making and outfitting hardware?

Practical experience has elucidated at least three reasons for the appearance of this formula: The first of these (the most inoffensive) is the insufficient technical competence of writers of documents (as a rule, non-specialists in problems of control automation); the second is the terminological sloppiness of specialists who underrate the consequences of using this terminology; the third, and the chief reason, is intentional use of word combinations of this sort for the purpose of laying the actual work and concern regarding outfitting ASU TP's on the shoulders of development organizations by defining outfitting operations by the word "make." In practice this approach to allocation of duties only complicates the matter, since supplying organizations are, as it were, relieved from performance of their real duties, and development organizations or plants which supply certain kinds of hardware cannot replace them since they have neither the legal nor financial capability in this question.

Still another aspect of the "Systems and Hardware" problem concerns the choice of the combination of hardware for the ASU to be developed. At the

current time prototypes of systems are important above all to the extent that they can serve as the basis for future furnishing of national economic objectives, i.e., for "circulating" systems. Therefore, adopting each new efficient system for use involves answering the following fundamental questions: By whom, when, and in what quantity will supplies be made of all the new hardware used in this system?

The worth of new hardware for an ASU has come to be determined objectively even not so much by its merits as much as by the degree of preparedness of industrial production. This is consistent since the true national economic impact of developing a new ASU now consists in the wide employment of this scientific and technological achievement.

Not infrequently ASU development organizations in putting together a prototype select the road of independently designing new hardware. After their tests design and process revisions have to be made and heavy expenditures are required for setting up production, and, what is most important, available production capacities.

Know-how gained confirms the simple truth: Development and production of hardware for ASU TP's is a systematically unified process, and the apparent gains made by independent development outside of the appropriate production associations are turned around in a number of instances by a real loss for the national economy. Of course this does not apply to the creation of industrial mockups used to check the principles and effectiveness of new solutions, to issue assignments for OKR, and to follow up with introduction according to plan.

A change in the scope and conditions for carrying out operations cannot but require qualitative changes in the methods and rules for carrying them out and, in particular, observance of strict industrial procedure in the course of creating the latest hardware for ASU TP's.

A number of important measures aimed at improving systematization of creating ASU TP's and putting them into operation have been defined by decree of the USSR Council of Ministers. Completion of this comprehensive program is conducive to increasing skills, to the most rapid mastery of the most advanced methods of designing ASU's, to maximum utilization of the capabilities inherent in domestic technology, and to improvement of the forms and methods of carrying out our work.

/The five-year plan of efficiency and quality cannot but be a five-year plan of systems automation./ [in expanded type]

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GEOPHYSICS, ASTRONOMY AND SPACE

WEATHER SERVICE SATELLITES

Moscow ZEMLYA I VSELENNAYA in Russian No 5, 1977 pp 16-24

[Article by Professor M. A. Petrosyants, Director of the USSR Hydrometeorological Center]

[Text] Methods for observing the atmosphere from space have taken a solid place in meteorology. A special branch of atmospheric science -- satellite meteorology -- has taken shape and is acquiring strength.

Meteorological satellites must satisfy special and very rigid requirements. In particular, they must form a constantly operating system with an extremely high degree of reliability, supplying information at definite hours of the day to users -- prognostic centers of different levels: from world meteorological centers to aerometeorological stations and individual vessels. It is clear that the system of meteorological satellites is in no condition to operate without a ground system for the reception, automatic processing and dissemination of satellite information. In the weather service there cannot be a situation when at the time of preparation of any forecast there is an absence of meteorological information, including from satellites. Accordingly, any irregularity in the continuous technological line of collection of information from satellites, be it the malfunctioning of a satellite in orbit or the malfunctioning of a component of the ground processing system, must be quickly eliminated.

The standardization of the apparatus carried on the satellite is very important. This requirement is fundamental not only for satellites of a single series. Adherence to such standardization will also probably favor successful international cooperation in this field.

Measurements From Space

In the last analysis, the source of information when making observations from space is the electromagnetic waves in different parts of the spectrum reflected or emitted by atmospheric or terrestrial objects. On the basis of the intensity of electromagnetic waves it is possible to judge some properties of the objects. Television cameras and scanning radiometers

on board a satellite and measuring the reflected radiation in the visible part of the spectrum (daylight) make it possible to obtain some idea concerning the form of objects with different reflectivity. The white sectors on the images correspond to regions with a great albedo and the black sectors correspond to regions with a low albedo. Thus, clouds will look white and water masses, for example, will look black.

Infrared scanning radiometers measure the long-wave (thermal) radiation emitted by clouds and the underlying surface of the earth. At a wavelength of $10\mu\text{m}$ the clouds and the earth's underlying surface emit as an ideally black body. In the wavelength range $8\text{--}12.5\mu\text{m}$ atmospheric absorption is minimum and IR radiation escapes into space with minimum losses. A scanning radiometer measuring radiation in the wavelength range $10.5\text{--}12.5\mu\text{m}$ will give some idea concerning the thermal relief of the underlying surface. Regardless of the time of day the dark sectors of the images correspond to the warmest regions of the underlying surface and the light sectors correspond to the coldest regions.

The radiation apparatus which measures the absolute radiation will register the heat fluxes escaping from the earth's surface and atmosphere and will give an estimate of the radiation balance of the earth-atmosphere system and the characteristics necessary for determining the temperature of the surface of the land and ocean. More precise spectrometric apparatus is used for measuring electromagnetic energy in very narrow spectral ranges, which makes it possible to compute the vertical distribution of temperature, humidity and ozone in the atmosphere.

All the necessary instruments are put into space by meteorological satellites put into circumpolar or geosynchronous (equatorial) orbits.

International Meteorological Service

Daily weather changes are caused by the development and movement of atmospheric disturbances -- waves and vortices whose horizontal extent is usually from 500 to 5,000 km. During a 24-hour period such disturbances can travel from 200-300 to 1,000-2,000 km. Therefore, for preparing a daily weather forecast it is necessary to have observations of the state of the atmosphere over an area measuring approximately $7,000 \times 8,000$ km. A forecast for three to five days already requires information at least from the territory of a hemisphere and a quantitative weather forecast for longer times is impossible without global information.

The atmosphere pays no heed to national boundaries. Understanding this, the meteorological services of a number of countries as early as 1873 created the International Meteorological Organization (now the World Meteorological Organization), which now has 144 members. A world weather service has been created within the framework of this organization. It joins the meteorological services of the member countries of the WMO into

a unified system consisting of a global observation system, as well as a global telecommunications system (data transmission system) and a global data processing system (ZEMLYA I VSELENNAYA, No 1, 1969, pp 4-8; No 1, 1973, pp 21-25. Editor's note). The global observation system has two subsystems: the surface subsystem -- synoptic and aerological surface stations, ships, aircraft, and the space subsystem -- polar and geostationary meteorological satellites.

The stations in the surface subsystem make observations at one and the same time over the entire earth and periodically send information on weather phenomena, temperature, pressure, humidity, wind direction and velocity at the earth's surface and in the free atmosphere. These data serve as a basis for constructing weather maps, carrying out a synoptic analysis and preparing a numerical weather forecast. An unquestioned advantage of the ground system is the synchronous nature of the observations, which makes it possible to obtain an "instantaneous photograph" of the state of the atmosphere, all the atmospheric disturbances prevailing at this moment and the weather associated with them. This makes it possible to compare the weather in different regions and to determine the stage in development of each atmospheric disturbance, each atmospheric object. However, such a system has obvious shortcomings: the stations are situated at different, sometimes very great distances and the observations are not made continuously but at definite time intervals (synoptic stations -- each three hours, aerological stations each 12 hours).

Thus, a synoptic analysis of the weather maps inevitably must use interpolation methods for determining the positions of the principal atmospheric objects -- fronts, cyclones and anticyclones, jet streams, tropical hurricanes and cloud clusters. Naturally, atmospheric disturbances whose horizontal dimensions are less than the distances between the stations and whose lifetime is less than the interval between observations will be missed. For meteorological observations at the earth's surface this is not very important, since atmospheric disturbances with a lifetime from 15 minutes and approximately to three or four hours make an insignificant contribution to the formation, for example, of the temperature field. But beginning with an altitude of 300-500 m such a "loss" of disturbances becomes significant.

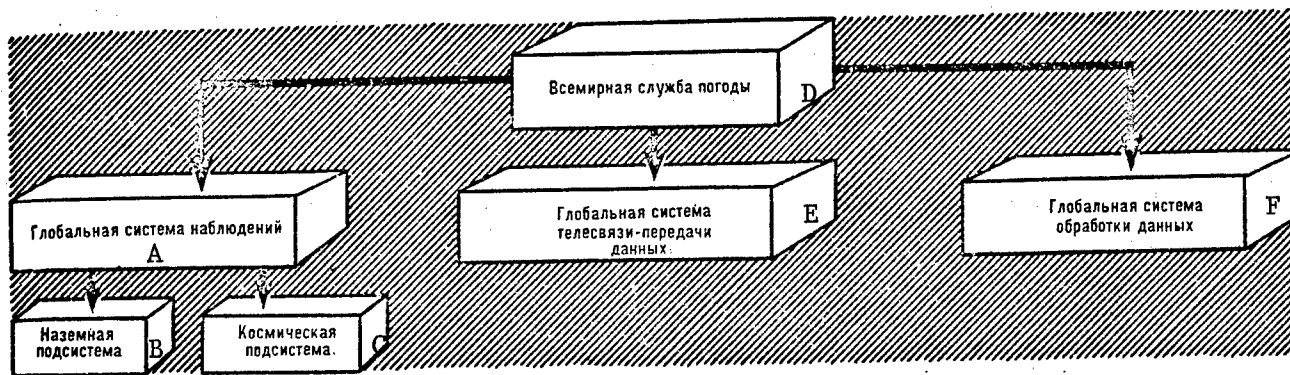
Another obvious shortcoming of the surface observation system is its spatial nonuniformity. The density of the network of stations satisfies the requirements of meteorologists only in Europe, North America and a large part of Asia. The southern hemisphere, the tropical latitudes, oceans in the northern hemisphere are inadequately covered by the observation network and therefore it is very difficult to represent the state of the atmosphere in these regions even approximately.

The information from the space subsystem, obtained using polar meteorological satellites, differs fundamentally from the information from the surface subsystem. The satellite collects and transmits data in the course of

motion in orbit and therefore the information is not synchronous. On the other hand, with a suitable organization of the space subsystem the information from the satellite is global. The meteorological data are plotted on the synoptic chart near the point where the station is situated. Information from polar satellites gives some idea concerning the form and dimensions of cloud fields and other atmospheric objects in the zone scanned by the satellite. The asynchronous nature of the information from these satellites somewhat complicates its use but the photographs taken from satellites and showing the synoptic situation in general put into the hands of meteorologists an unusually powerful tool for the analysis of atmospheric processes. Geostationary satellites are still more important for observations of the atmosphere.

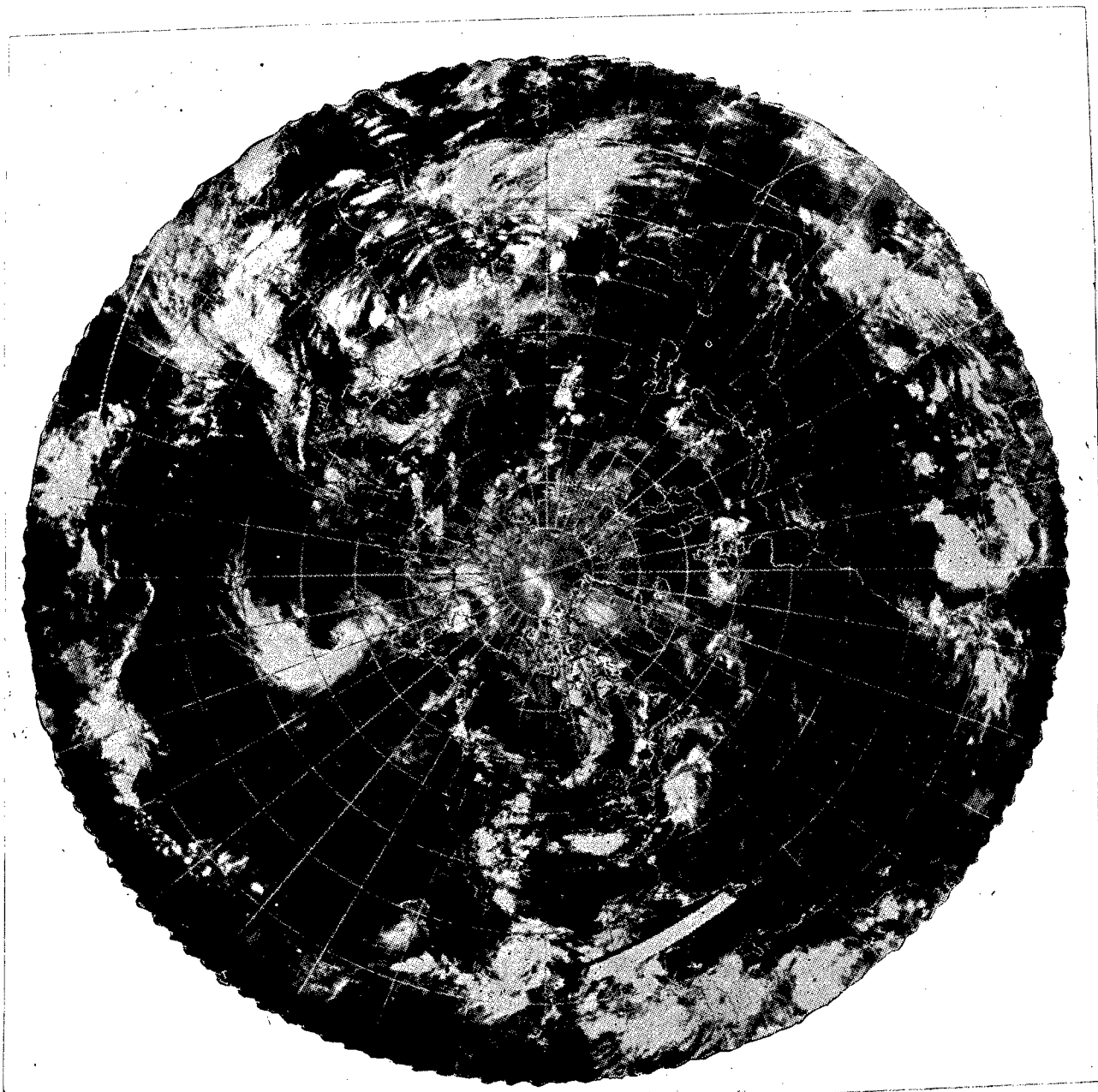
At the present time the operational space subsystem consists of the USSR "Meteor" polar-orbit meteorological satellites, the American NOAA satellites and the American SMS-1 and SMS-2 geostationary satellites. [NOAA -- National Oceanic and Atmospheric Administration; SMS -- synchronous meteorological satellite]

The Soviet "Meteor" satellites revolve around the earth at an altitude of about 900 km. The resolution of their television cameras at the nadir is 1.5 km and the scanning IR radiometer is about 20 km. The NOAA satellites fly at an altitude of 1,450 km; the resolution of their television cameras at the nadir is about 3.2 km and the resolution of the scanning IR radiometer is 7.4 km. They are supplied with special radiometers for measuring energy in eight intervals of the IR part of the radiation spectrum; this makes it possible to compute the profile (vertical distribution) of temperature from the earth's surface to an altitude of 30,500 m over an area of approximately 110 km².

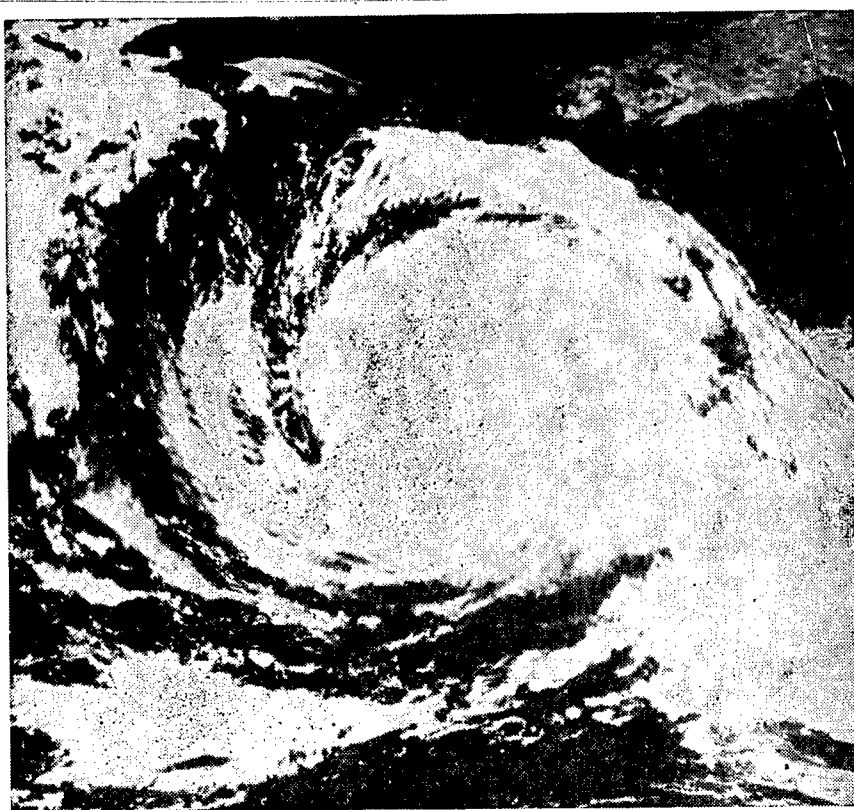


- A) Global observation system
- B) Surface subsystem
- C) Space subsystem

- D) World Weather Service
- E) Global system of telecommunication (data transmission)
- F) Global data processing system



Infrared image of cloud cover over northern hemisphere. It was obtained by the successive processing of photographs taken during 14 revolutions around the earth. The bright white spots are high clouds; the gray regions are fields of low clouds; the black sectors are cloudless regions over the oceans and continents. The enormous white "comma" in the left part of the photograph shows a region where there is dominance of a powerful cyclone with characteristic poor weather. The photographs were taken from the NOAA-4 satellite on 7-8 July 1975.



Television photograph of typhoon "Fran," which hit Japan in September 1976. On the basis of the nature of the cloud cover and the cloud spirals it can be judged that this typhoon attained hurricane force (wind velocity greater than 33 m/sec) and unquestionably is a great danger. The photograph was taken on 10 September 1976 from the "Meteor" satellite.

Effectiveness of Satellite Information

More than 10 years of experience with the use of satellite information has unusually enriched our knowledge of the atmosphere. In particular, TV and IR photographs of the cloud cover have remarkably confirmed the correctness of our ideas concerning the structure of cloud systems -- warm and cold fronts, cyclones and anticyclones, jet streams and tropical hurricanes and about changes in cloud systems in the process of evolution of these formations, ideas which were formulated by meteorologists as a result of analysis of ground observations. The cloud systems which are visible on the TV and IR photographs clearly define the macroscale peculiarities of atmospheric circulation.

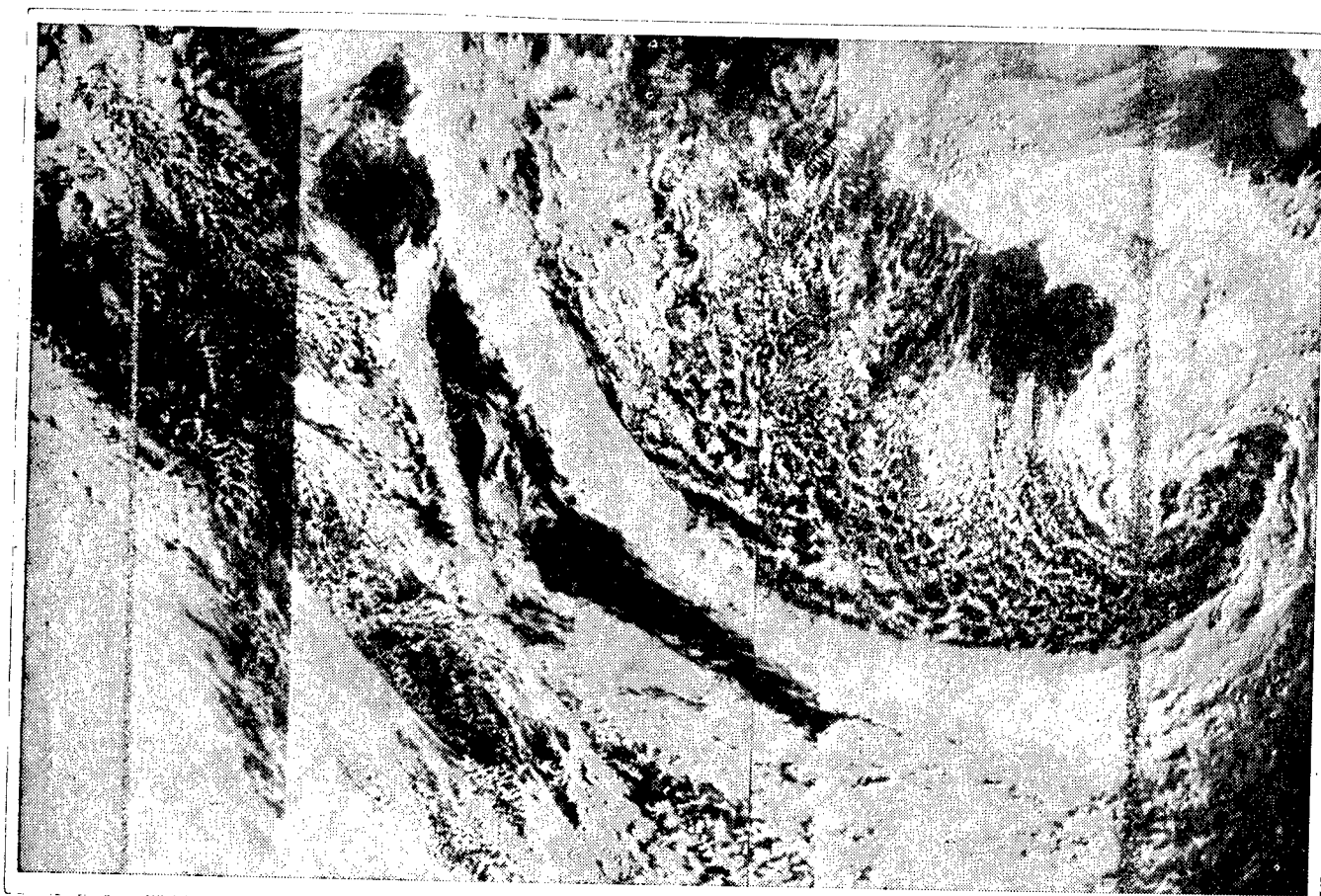
It is extremely effective to study tropical cyclones from photographs taken from satellites (ZEMLYA I VSELENNAYA, No 5, 1971, pp 37-44. Editor's note). For understandable reasons there have not been many surface observations in tropical cyclones. Satellites have done what it was difficult for people to

do: they have more precisely defined the stages in the development of cyclones and the weather associated with them. The information obtained from satellites made it possible to create a service for warning about tropical cyclones. Using photographs from satellites it could be established that some regions in the Pacific and Indian Oceans earlier considered free of tropical cyclones and therefore safe for navigation in actuality are not such because they are frequently visited by severe hurricanes.

A combination of satellite maps of cloud cover and ordinary maps of weather at the earth's surface and maps of air currents in the free atmosphere gives the most complete picture of atmospheric movements at every moment in time. Such an analysis has become a daily procedure at all present-day meteorological centers. However, photographs of cloud cover taken from satellites not only assisted in analyzing macroscale circulation systems but also opened up a whole world of earlier unknown meteorological phenomena with horizontal dimensions of about 10-100 km.

The most interesting results were obtained in an investigation of convective processes. Thus, it was found that in the atmosphere there are two types of convective elements -- closed and open. In closed convective cells ascending movements are observed at the center of the cell, whereas there are descending movements along its periphery. In open cells the picture of ascending movements is the opposite. A TV photograph of the clouds in the Kamchatka region tells the nonspecialist little. But to the eye of the meteorologist the photograph tells much. Synoptic scale systems are traced on it. The distinct edge of the upper boundary of cloud cover in the southwestern corner determines the position of the axis of a jet stream, a river of rapidly moving air with a velocity maximum in the layer 8-12 km. In the north, somewhat to the east of Kamchatka, there is a center of a cyclone with an active cold front, behind which there is an intrusion of cold air onto the relatively warm sea surface of the Sea of Okhotsk. A whole world of mesometeorological formations is developing in the rear (behind the front). In the northern cold air mass (behind the front), as a result of convection, one can observe the development of open convective cells having the configuration of rather regular hexagons. In the southern part of the air mass intruding behind the cold front it is possible to see closed convective cells. This is indicative of the conditions for air mass transformation: in the northern part it is heated from the sea, whereas in the southern part it is cooled. Farther to the west one can see ridges of wavelike clouds indicating the existence of a temperature inversion and gravitational waves in it.

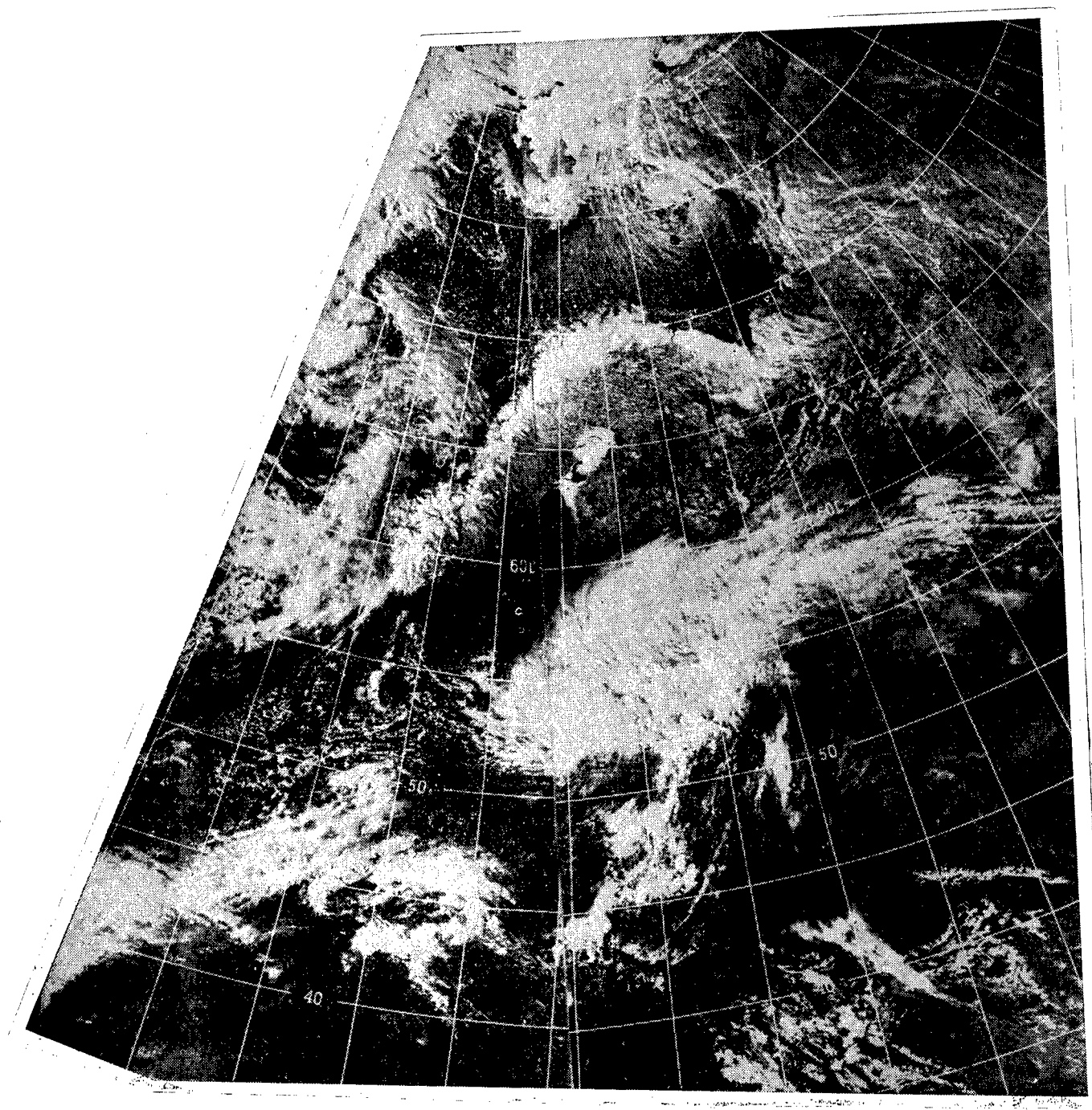
Extensive information is contained in television photographs of cloud cover in mountainous regions and in regions where air currents collide with obstacles. Television photographs of cloud cover in the mountains, in the case of a sufficiently great resolution, make it possible to reconstruct the complex pattern of air currents. And if the information extracted from a television photograph taken from a satellite arrives systematically on the weatherman's desk and at the necessary time, its importance for local weather forecasting is difficult to overevaluate.



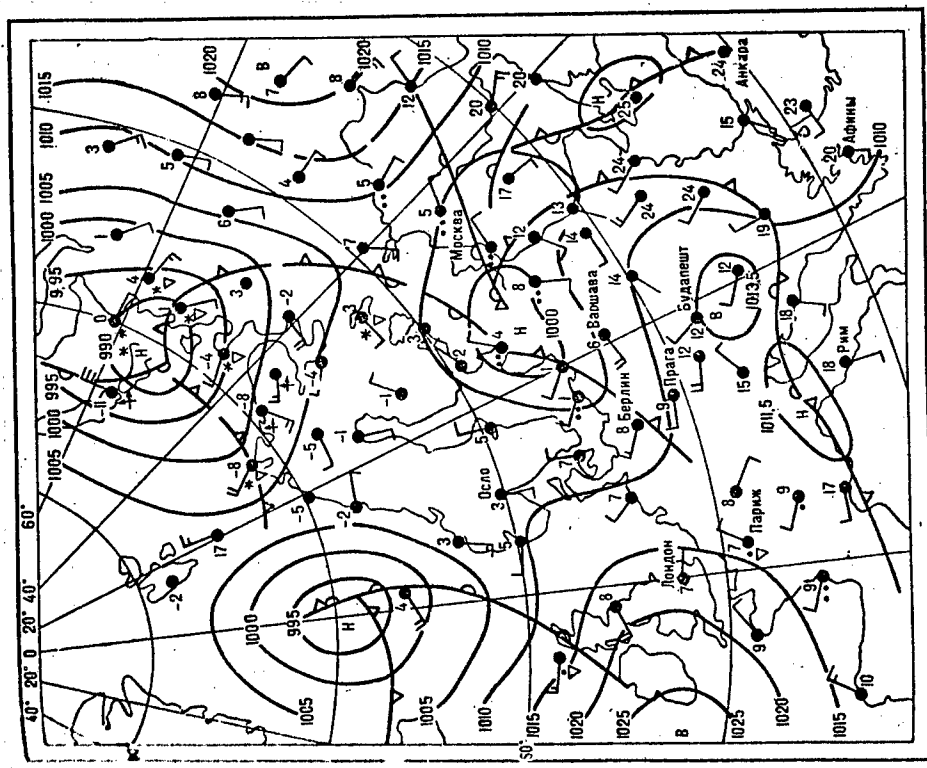
Television photograph of cloud cover in Kamchatka region taken on 15 November 1975 from the "Meteor" satellite

The possibilities of satellite methods for making atmospheric observations are by no means exhausted and can provide the weather service considerably more information than now. In the "Fundamental Directions in the Development of the National Economy of the USSR During 1976-1980" we read: "...and broaden research on the use of space technology in study of the earth's natural resources, in meteorology, oceanology..." This also applies to improvement of a routinely operating meteorological satellite system.

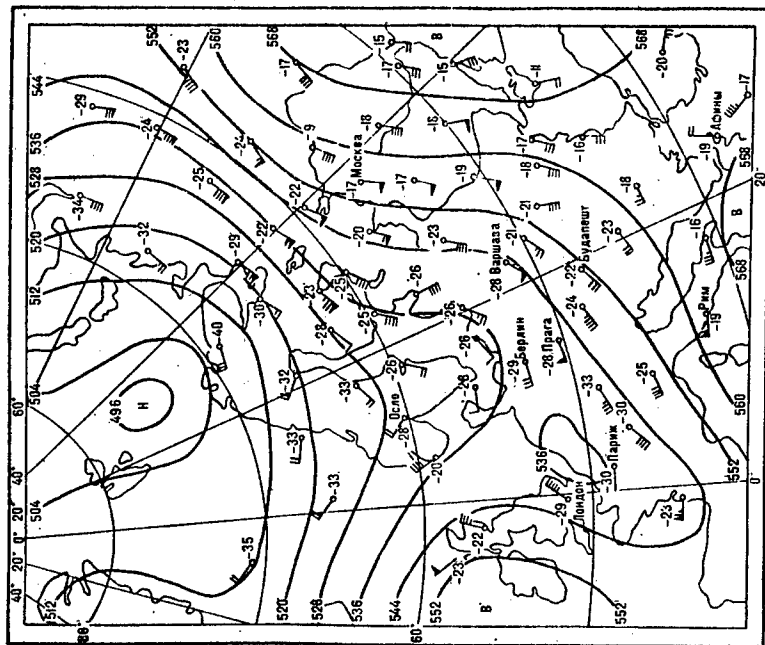
The development of methods for forecasting for times greater than five days requires that sufficiently precise observations of the state of the atmosphere, ocean and land be made uniformly over the entire earth. The only possibility of creating such an observation system is an optimum combination of surface and satellite observation subsystems. First of all it is necessary to create such a routinely operating service for the monitoring of clouds which would give some idea concerning the global distribution of



Cloud systems of cyclones photographed from "Meteor-2" satellite at 1400 and 1600 hours Moscow time on 4 April 1977 over Europe.

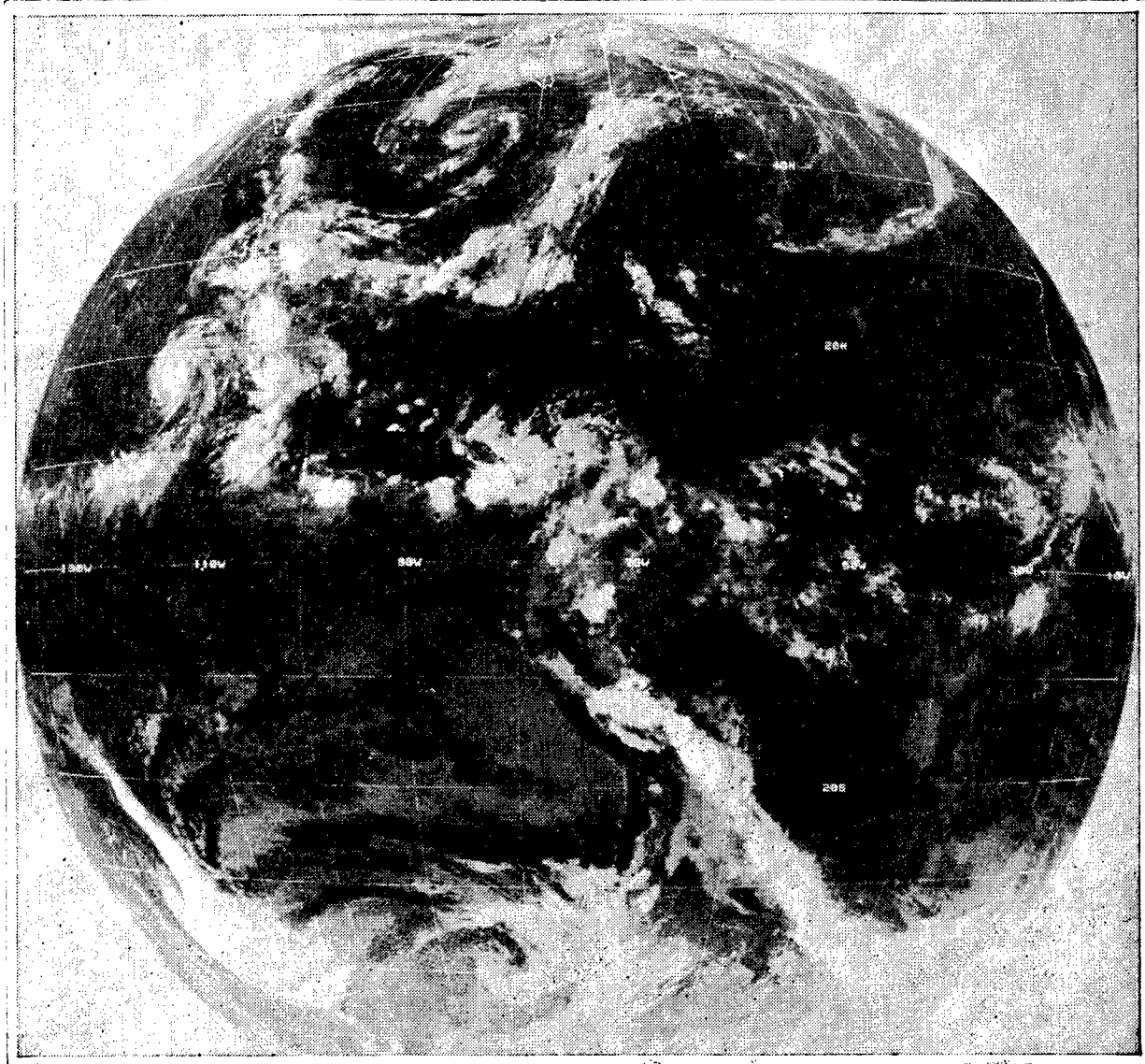


Weather map at 1500 hours Moscow time on 4 April 1977 demonstrating position of fronts, cyclones (low-pressure regions), anticyclones (high-pressure regions), wind directions and velocities, temperature and cloud cover at earth. Symbols: solid curves -- isobars (equal pressure lines), small circles -- station symbols, arrow with fins -- wind direction and velocity, figures -- temperature, dots denote rain, asterisks -- snow, triangle with dot -- showers



Map of direction and velocity of air currents and temperature field in troposphere in layer 5-6 km above the earth's surface. Symbols: solid curves -- lines of equal altitudes of 500-mb isobaric surface, arrow with fins -- wind direction and velocity, figures -- temperature

cloud cover twice a day. The data should be represented not only graphically, but also be characterized by a number, for example, by the average tenths of cloud cover in a definite area. In addition to daily information, in the surface processing system provision must be made for obtaining maps of the mean cloud cover for periods of five, ten days and a month. Such data are necessary for creating more precise methods for long-range



Infrared photograph taken on 12 July 1975 from a geostationary satellite.

It is necessary that vertical sounding of temperature and humidity from satellites become permanent. Since by soundings from satellites it is possible to determine the mean temperatures of atmospheric layers of rather

great thickness, it is necessary to carry out an investigation of a rational combination of satellite and surface observations which would make it possible to reconstruct the pressure field in the atmosphere. It is also necessary to know the temperature of the ocean surface with a great accuracy.

The World Meteorological Organization and the International Council of Scientific Unions are preparing a grandiose scientific measure -- the First Global Experiment -- under the GARP program, which it is planned will be carried out in December 1978 - December 1979. During this experiment a global observation system should be organized which will make it possible to obtain a year-long series of quite precise data on the state of the atmosphere, land and ocean, necessary for creating and checking numerical long-range weather forecasting models. An important part of this system will be five geostationary satellites which will occupy the following points on the equator: 0° longitude (European Space Agency), 70°E (USSR), 140°E (Japan), 135°W (United States).

Geostationary satellite make it possible to obtain TV and IR images of the earth's surface in the latitude zone 50°N - 50°S with three resolutions (1 km; 3.2 km; 6.4 km) each 30 minutes. Thus, a photograph from a satellite carries information on a simultaneous scanning of the atmosphere, that is, has a synoptic nature, and the set of photographs taken each 30 minutes makes it possible to assume that the observations are made continuously. Using these photographs it is possible to trace the movement of clouds and obtain data on the wind in the tropical zone where these data are most lacking. It is difficult to overevaluate the advantages from creation of such a system.

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GEOPHYSICS, ASTRONOMY AND SPACE

THE OCEAN AS SEEN FROM SPACE

Moscow ZEMLYA I VSELENNAYA in Russian No 5, 1977 pp 25-28

[Article by Doctor of Physical and Mathematical Sciences K. N. Fedorov and V. Ye. Sklyarov]

[Text] The world ocean, occupying two-thirds of the earth's surface, is not only an important, but also a complex object of investigations. Accordingly, the ability to glance into it from space, seeing it as a whole, is of particular value for science.

The time has long past when formulation of the problem of investigation of the ocean from space could cause only perplexity. The successes of space technology and instrument making have considerably broadened the field of applicability of space vehicles. Remote methods for geophysical measurements have been developed and used. Satellites have appeared which are designed for observations of the environment. All this made it possible for the first time to give a real evaluation of the advantage of study of the earth's surface and world ocean from the altitude of space orbits.

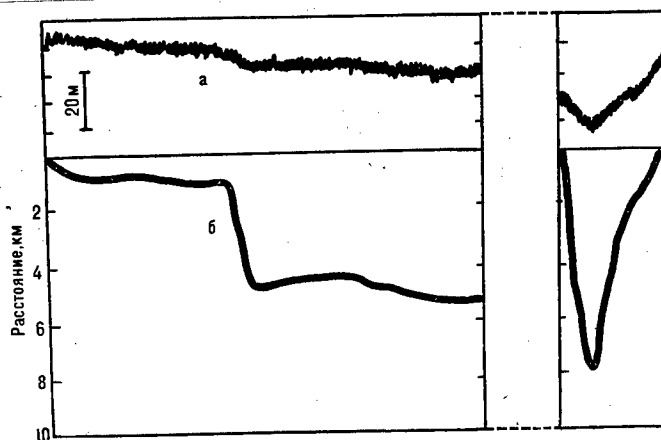
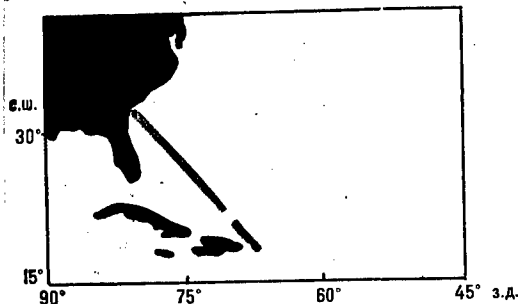
Over the course of many years oceanologists collected bits of information concerning the ocean, data collected by individual fragmented expeditions. They never could cover the world ocean with an overview because the organization of a network of permanent observation stations in the ocean was beyond their capability and was too expensive an undertaking. Only during recent years, and especially due to international cooperation, was it possible to carry out several prolonged major expeditions somewhat clarifying the synoptic picture of the world ocean (ZEMLYA I VSELENNAYA, No 3, 1971, pp 6-16. Editor's note). Powerful eddies, somewhat similar to atmospheric cyclones and anticyclones, were discovered in the ocean (ZEMLYA I VSELENNAYA, No 1, 1974, pp 9-16. Editor's note). The complex pattern of interaction between the ocean and the atmosphere became more understandable (ZEMLYA I VSELENNAYA, No 3, 1971, pp 17-24. Editor's note). New currents were plotted on the maps (ZEMLYA I VSELENNAYA, No 1, 1970, pp 87-88. Editor's note). Our knowledge of the variability of the physical, chemical and biological processes in the ocean was broadened and supplemented. And now, finally, a means has appeared making it possible to pull together the individual parts of the complex picture, glance into the ocean, which is continuously changing and in continuous movement, as an integrated whole.

And the means by which this is done is space laboratories, which make it possible to collect extremely valuable and sometimes unique scientific information concerning the ocean.

For example, IR radiometers even from an altitude of several hundred or thousand kilometers can measure the temperature of the sea surface with a spatial resolution of only several kilometers and with an accuracy of about 1°C. Temperature measurements are also possible in the microwave range of the electromagnetic spectrum and in the latter case the measurements will not be hindered by either clouds or moisture present in the atmosphere and greatly attenuating the IR radiation passing through it. Observations of the heat field of the ocean by means of a combination of different instruments are thus possible in any weather and at any time of day. On the images obtained from satellites in the IR range it is easy to see the boundaries of warm and cold currents in the ocean, ocean eddies and regions covered with ice. Radiothermal and radar measurements from satellites give information on the state of the sea surface: altitudes and nature of wind waves, wind and current velocities. A radar can also operate on a satellite as a radioaltimeter and increase the accuracy and resolution of the measurements to such a degree that it will be possible to measure the level excess of the ocean surface associated with wind-induced changes, tides, currents and destructive waves -- tsunamis.

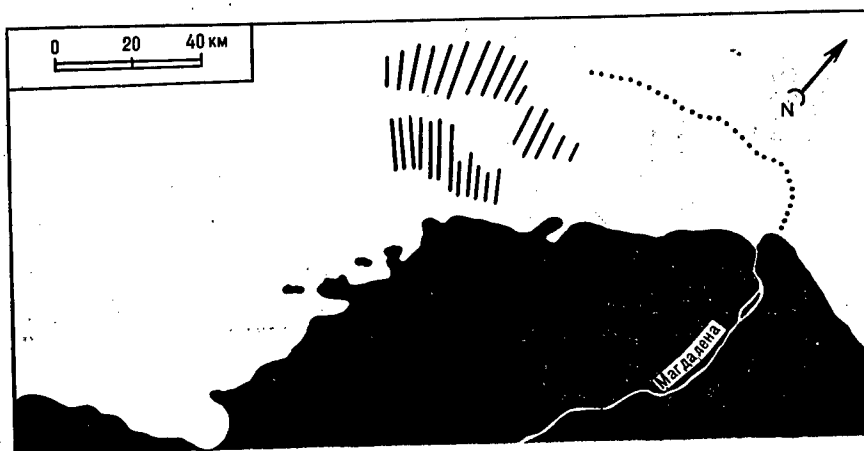
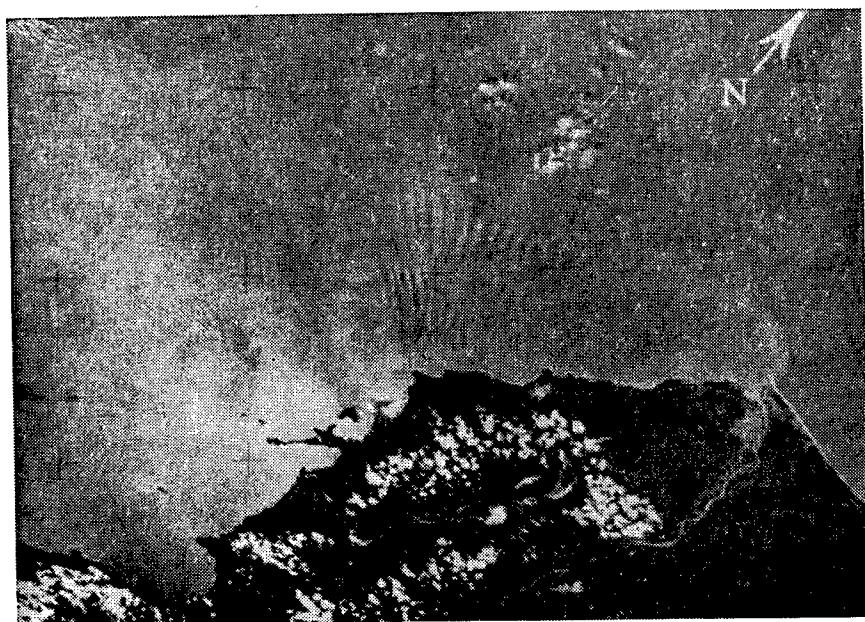
Even now interesting results have been obtained using the orbital radioaltimeter. When the "Skylab" space laboratory flew over the region of the legendary Bermuda triangle, using radioaltimeter data it was easy to see the difference in the slopes of the northern and southern sides of the decrease in ocean level in full accordance with the slopes of the floor of the depression near Puerto Rico. Without question the discovered curvatures of the ocean surface are part of the complex configuration of the geoid and are in gravitational equilibrium. Accordingly, water cannot with a vigorous rate move into the discovered level decreases. Leaving to one side different sensational and unusual communications appearing in the press concerning "funnels" and "sinks" discovered in the Bermuda triangle, I would like to note the presence of a clear relationship between the changes in ocean level and bottom relief, which is unquestionably of great scientific interest.

Modern optical instrumentation makes it possible to register many highly interesting phenomena occurring on the ocean surface in the visible range of the spectrum. Zones of increased biological productivity in the ocean are characterized by color changes due to the presence of very tiny algae (phytoplankton) containing chlorophyll. Internal waves are formed and are propagated in the depths of the ocean and it would seem should not be visible from the surface. Nevertheless, they interact with surface wind waves, leaving characteristic traces on the ocean surface. From these traces it is possible to determine important parameters of oscillations of internal layers in the ocean. In some cases there are also other factors ensuring the possibility of observation of internal waves from space. For example,

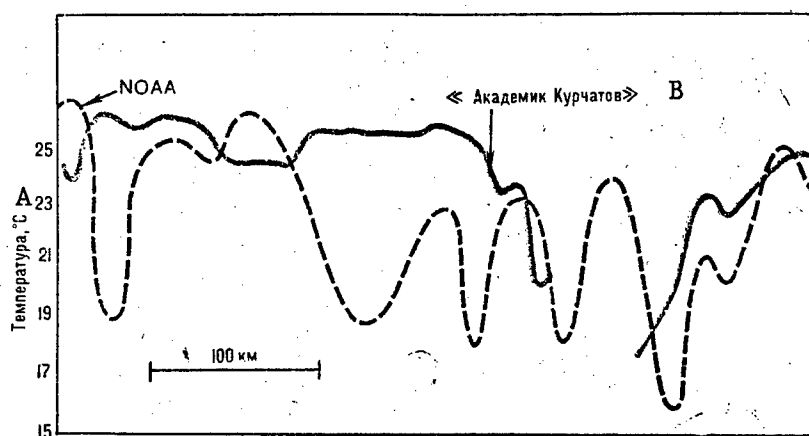
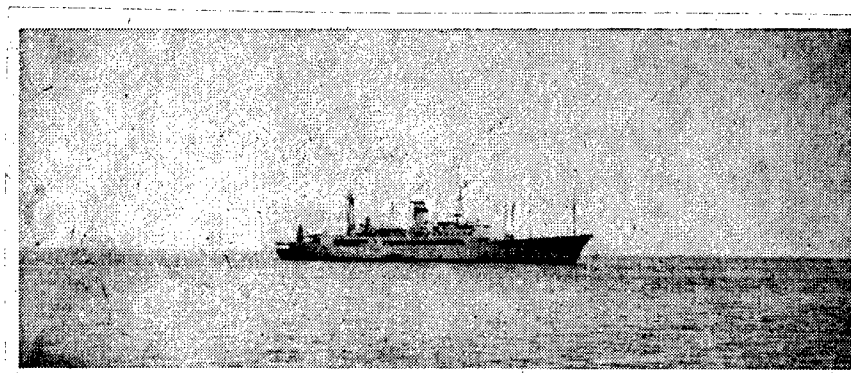


Region and path of measurements from shores of South Carolina to point south of Puerto Rico; a) profile of ocean level (according to data from radioaltimeter of "Skylab" space laboratory); b) curve corresponding to profile of ocean floor. Annotation: distance, km

Internal waves along shores of Colombia in Caribbean Sea. Photo taken from the "Skylab" space laboratory. Published in SEA FRONTIERS, 20, 6, 1974. Diagram is given for clarity.



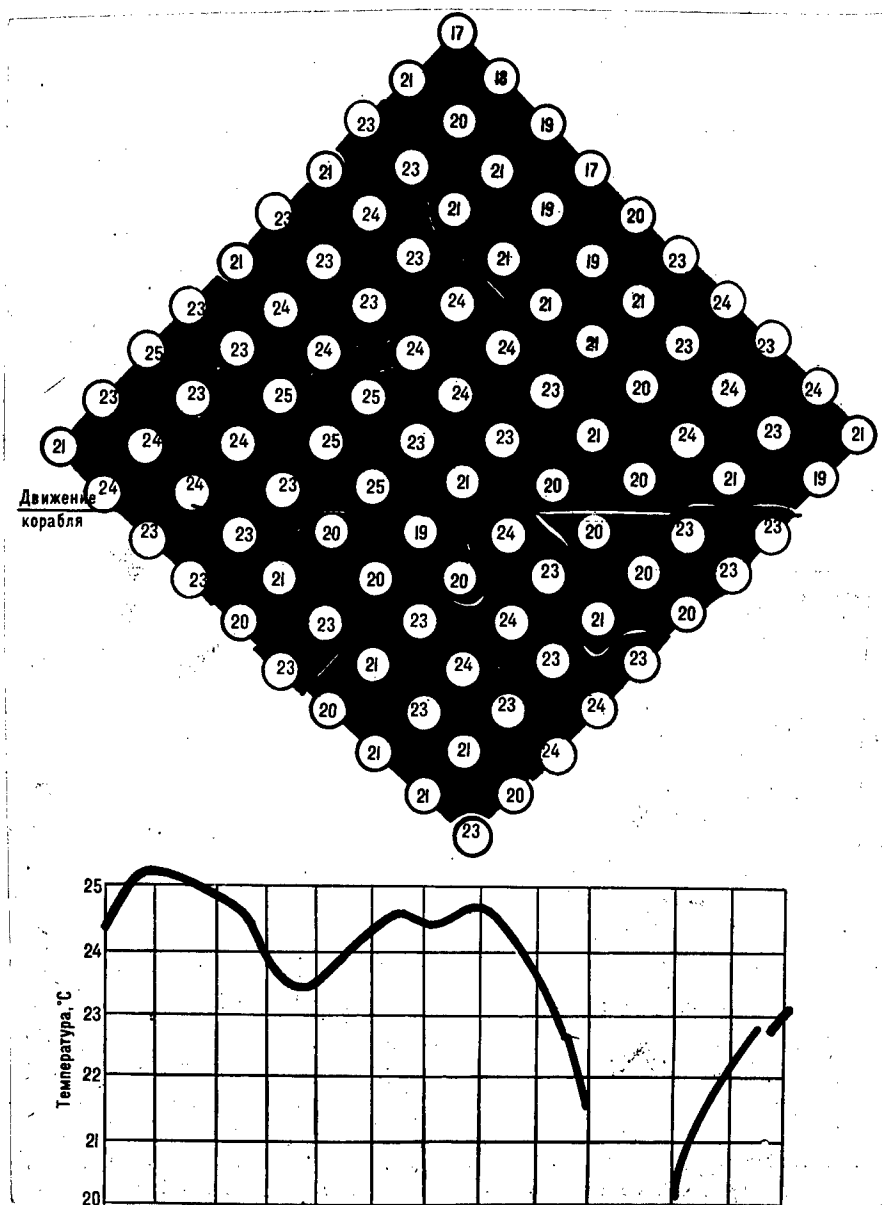
in the Caribbean Sea along the shores of Colombia, where the Magdalena River flows in, whose turbid waters are propagated along the shore, forming a distinct discontinuity with the purer waters of the Caribbean Sea. The internal waves can be seen particularly clearly in the zone of turbid waters, where usually there are groups of alternating light and dark zones almost perpendicular to the shore. The observed phenomenon can evidently be attributed to the fact that on the crests of the internal waves the layer of turbid water is thicker and looks lighter on the photographs.



TOP: Scientific research vessel "Akademik Kurchatov" in the Indian Ocean during joint work with the American satellite NOAA-4. BOTTOM: Synchronous measurements of ocean temperature in region of Gulf Stream carried out from ship and satellite. A) Temperature; B) Kurchatov

There are very important satellite methods for making measurements in the infrared, microwave and visible ranges for detecting regions of ocean contamination (for example, petroleum films). Considerable progress has been

made in the development of these methods so that even now it is possible to speak seriously of the organization of a service for observing purity of the ocean.



Distribution of temperature in the Atlantic Ocean in the region of the Gulf Stream constructed on the basis of satellite data with the use of the filtering method. It is easy to see the warm and cold parts of the ocean (the figures are for temperature, in °C). In the lower part of the figure we have shown the results of temperature measurements on this same day from the scientific research vessel "Akademik Kurchatov." The data obtained in the ocean and from space agree quite well. Upper annotation: ship movement; lower annotation: temperature, °C

The enumerated examples by no means exhaust the role of artificial earth satellites in the development of oceanological research. A satellite may or may not make direct measurements or observations of the ocean from space. But using it it is possible to organize regular collection of data from automatic measurement stations at anchor or drifting in the ocean. Using satellites it is possible to obtain constantly the coordinates of radio buoys or icebergs freely drifting in ocean currents and thus study the circulation of waters in the ocean or warn ships about the danger of collision.

At the present time we have experience from two experiments with the setting out of radio buoys on icebergs in the Atlantic waters. In the first experiment (1972-1974) the radio buoy signals were received by the French EOLE satellite; in the second (1975-1977) they were received by the "Nimbus-F" American satellite. The trajectories of drifting icebergs determined in these experiments gave interesting information on the peculiarities of circulation of waters near the shores of Antarctica. For example, there was found to be a northward deflection of the coastal Antarctic Current in the sector bounded by the meridians 80 and 100°W.

Finally, systems of navigation satellites make possible a very precise (to tens of meters) determination of the position of ships (including scientific) in the ocean, which is unusually important in many types of research.

For the time being it is still more expensive to launch satellites into space than to send ships with scientific expeditions to sea. This circumstance forces oceanologists to make very careful preparations for the assimilation and interpretation of this information on the ocean, which in the not distant future will begin to arrive regularly from space orbits. New types of information require new types of mass processing, but in order to achieve a reliable result it is also necessary to carry out many additional investigations.

Great hopes for study of the ocean rest with international cooperation. It must be said that already the first steps in such cooperation have brought significant results. For example, specialists of the Institute of Oceanology imeni P. P. Shirshov of the USSR Academy of Sciences in 1973 and 1976 measured water temperature at the surface of the Atlantic and Indian Oceans. Simultaneously IR measurements were made by American artificial earth satellites of the NOAA series. Analysis of satellite information indicated that maps of ocean temperature obtained from satellites are excessively detailed. The details distort the real distribution of ocean temperature. This is caused by the influence of instrument noise and the clouds in part entering into the field of view of the radiometer aboard the NOAA satellite.

The authors of this article used the optimum filtering method for interpreting the measurements described above. This method uses information on the statistical structure of the temperature field of the ocean. Using it, to a considerable degree it was possible to "suppress" instrument

noise and determine the temperature of sectors of the water surface covered by clouds.

Now only the first steps have been taken in study of the world ocean, but the "Fundamental Directions in the Development of the National Economy of the USSR for 1976-1980" provided for a broadening of the means and methods for investigating the earth's resources from space. It can be hoped that in the next few years Soviet space vehicles will make regular scientific observations of the world ocean.

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LASER RANGEFINDERS IN SATELLITE GEODESY

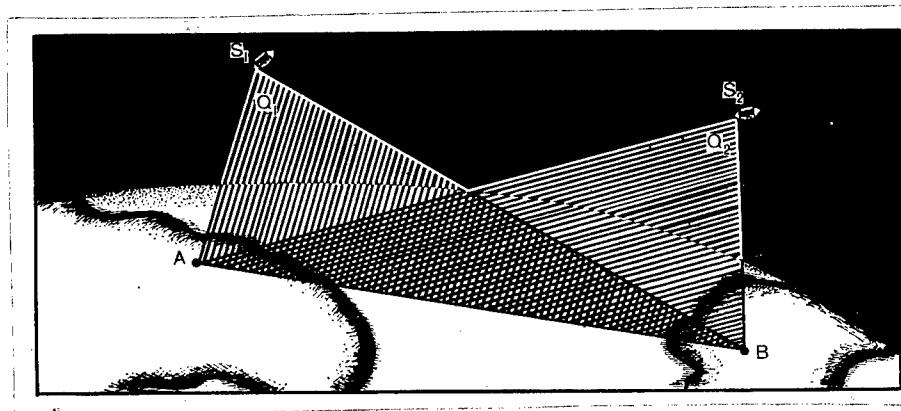
Moscow ZEMLYA I VSELENNAYA in Russian No 5, 1977 pp 34-41

[Article by Candidate of Physical and Mathematical Sciences N. P. Yerpylev]

[Text] Laser rangefinder observations of satellites already in the immediate future will make it possible to increase the accuracy in determining distances on the earth's surface to several centimeters.

Space Triangulation

The creation of a network of geodetic control points on the earth's surface with reliably determined coordinates is one of the most important tasks in geodesy. Such networks are used in refining the figure and dimensions of the earth, in cartographic work, in solving many applied problems in geodesy, geophysics and geodynamics.



Geometrical method of satellite geodesy. In order to find the direction of the terrestrial chord AB, photographs are taken simultaneously of the satellite S_1 and then the satellite S_2 from the stations A and B. The computed pairs of directions AS_1 , BS_1 and AS_2 , BS_2 determine the planes Q_1 and Q_2 , the line of whose intersection coincides with the direction of the chord AB.



Orbital method in satellite geodesy. On the basis of satellite observations at the points S_1, S_2, S_3 from the stations A and B, whose coordinates are known, it is possible to refine the orbit and then compute the positions of the satellite at the times when it was observed from station C. The coordinates of the satellite at the points S_4, S_5, S_6 and the directions CS_4, CS_5, CS_6 obtained from observations make it possible to compute the coordinates of station C.

In geodetic practice all methods for determining the relative position of control points are usually based on measurement of the directions of the straight lines (terrestrial chords) connecting the points and the distances between them. In order to carry out measurements by the methods of classical geodesy it is necessary from each point to see targets set up at several other points. The distance between points, even if high geodetic towers are constructed at them, cannot exceed several tens of kilometers (in the mountains -- a little more). It is evident that in this way it is impossible to ensure a geodetic tie-in of remote islands to the continental coordinate system, much less to create intercontinental networks of geodetic control points. This problem is solved by space triangulation methods.

Space triangulation has considerably broadened the possibilities of geodesy (ZEMLYA I VSELENNAYA, No 3, 1968, pp 14-22. Editor's note). There is no longer a need for a visual connection between the ends of the chord when determining its direction. For this purpose it is sufficient to photograph against the star background, simultaneously from both points, some bright object raised high above the earth's surface. It can be an aerostat (balloon), supplied with a powerful pulsed light, or an artificial earth satellite. In balloon geodesy the length of the chord was increased to 200 km; in satellite geodesy -- up to several thousand kilometers.

Each pair of satellite photographs (satellite pair), obtained simultaneously from both ends of the chord, makes it possible to determine the spatial orientation of the plane which passes through three points -- the observation stations and the satellite at the time of its photographing. The intersection of two such planes corresponds to the sought-for direction of the chord (in actual practice 30-40 pairs of satellite photographs). This satellite geodesy method is called the geometrical method.

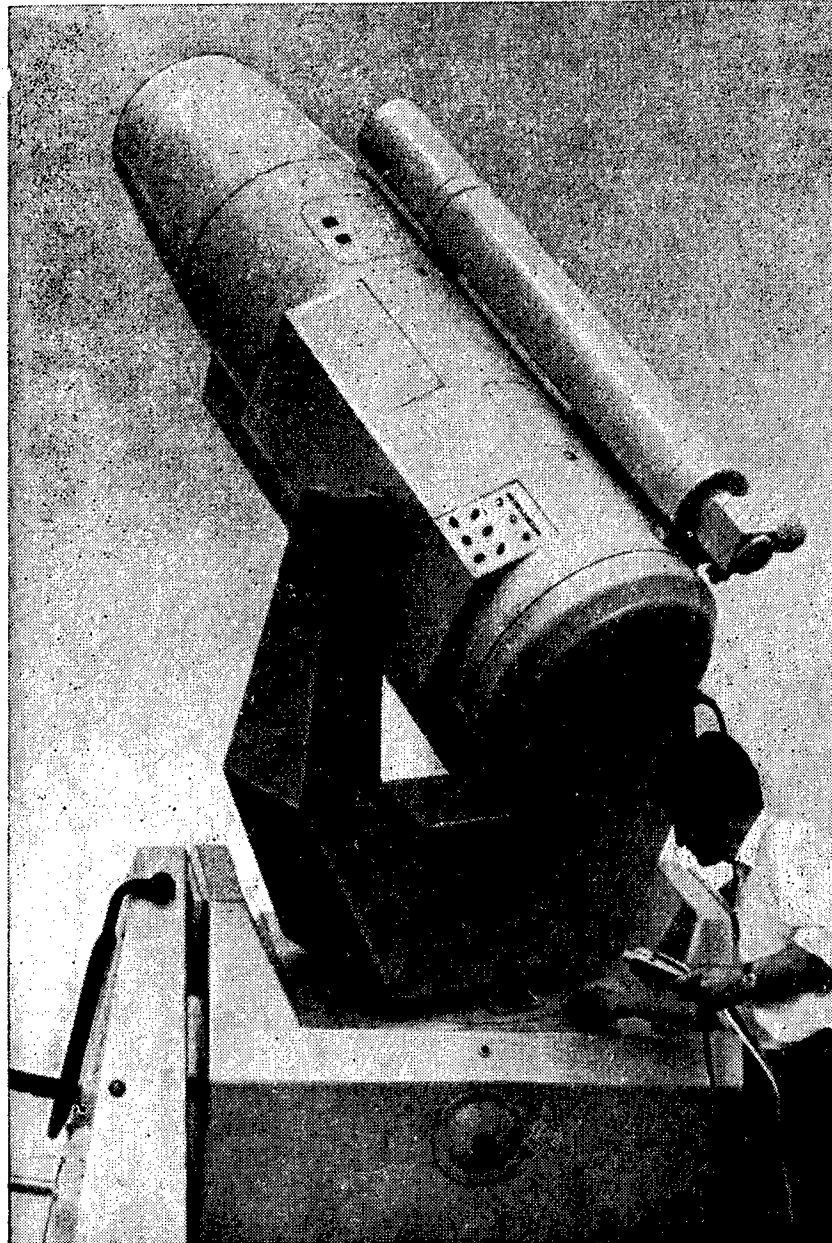


AFU-75 camera (USSR) used for the observation of artificial earth satellites.

In contrast to the geometrical method, the orbital satellite geodesy method does not require simultaneous observations at all. It can be used for the geodetic connection of stations at any distance from one another.

The first studies in the field of satellite geodesy were carried out in 1961 on the initiative of the Astronomical Council USSR Academy of Sciences and the Main Astronomical Observatory USSR Academy of Sciences at four Soviet observatories (ZEMLYA I VSELENNAYA, No 1, 1965, pp 11-16. Editor's note).

Since that time satellite geodesy methods have received recognition in geodetic practice.



SBG camera fabricated by the People's Enterprise "Karl Zeiss Jena" in the GDR. This camera is used at many stations for optical observations of artificial satellites.

The investigations are carried out in an extensive network of stations for optical observations of artificial earth satellites created in a program of cooperation between the Astronomical Council USSR Academy of Sciences and a number of foreign scientific institutions. Participating in the observations are stations located in the Soviet Union, German Democratic Republic, Poland, Czechoslovakia, Hungary, Rumania, Bulgaria, Korea, Cuba, Egypt, Sudan, Somali, Chad, Mali, Equatorial Guinea, French Guiana, Ecuador, India, on Amsterdam Island in the Indian Ocean, and in the Spitzbergen Archipelago (up to 1975 there was a station in operation on Kerguelen Island in the Indian Ocean). All the stations make observations under unified programs and are supplied with standard instruments -- automated satellite camera on four-axis mountings fabricated in the USSR (AFU-75) and GDR (SBG).

Thus, on the basis of photographic observations of satellites it is possible to determine the directions of the chords connecting the observation stations. However, this did not solve the problem of creating a network of geodetic control points by a method not dependent on classical geodesy. The measured directions make it possible to clarify the configuration of the network of stations and tell nothing about the distances between them. The scale of the network can be determined by including in it at least two stations with coordinates known from terrestrial geodetic measurements. But this same objective can be achieved in a different way -- by learning to measure distances to a satellite.

How is Distance to a Satellite Measured?

Modern technology has at its disposal extremely modern methods for determining distances, but by no means are they all suitable for solving geodetic problems. Radar has also not found application in space geodesy. In order to receive a reflected radio signal from a small satellite which is many thousands of kilometers distant, it is necessary to have extremely powerful stationary radars. It is impossible to supply them to the numerous stations in the geodetic network. However, other radioengineering methods were found to be applicable.

One of these is based on the continuous registry of the Doppler frequency shift of a radio signal as a result of the relative motion of a radio transmitter mounted on a satellite and a receiver at an observation station. Repeating such measurements during many satellite transits, with an accuracy to several meters it is possible to ascertain the position of an observer. In another radioengineering method the measurement of distance to a satellite is based on use of a modulated radio signal. The signal is directed to the satellite, activates thereon instrumentation for emitting a response radio signal. The phase difference between the emitted signal and the response signal received from the satellite makes it possible to compute the time expended by the radio signal on the double path from the observer to the satellite and then on the basis of the known velocity of radio signal propagation to find the distance to the satellite. By this method the distance is measured with an accuracy to 10 m.

But the most reliable measurements of distances to a satellite are ensured by laser rangefinder observation methods. Even now the accuracy of such measurements attains 10-20 cm.

For the first time the laser ranging of artificial earth satellites was accomplished in the mid-1960's in the United States, France, Japan and some other countries. Early in the 1970's the scientific institutions in a number of socialist countries participating in joint investigations of space proceeded to the creation of a laser satellite rangefinder. The coordination of work was assigned to the Astronomical Institute of the Czechoslovakian Academy of Sciences and the Czech Technical University at Prague.

In the spring of 1972 at the Ondrjevo Astronomical Observatory (not far from Prague) tests were carried out of the first laser satellite rangefinder. The tests were crowned with success and work began on the assembly of several rangefinders adapted for work under expeditionary conditions. A second rangefinder, after testing at Riga, was installed in 1974 at one of the key stations in the international network -- at Helwan (Egypt). In the years which followed these rangefinders, given the name "Interkosmos" rangefinders, were supplied to stations at Patacamaya (Bolivia), Borowiec (Poland), Cavalura (India). Laser rangefinders were also installed at Simeiz and Zvenigorod (USSR) and Potsdam (GDR).

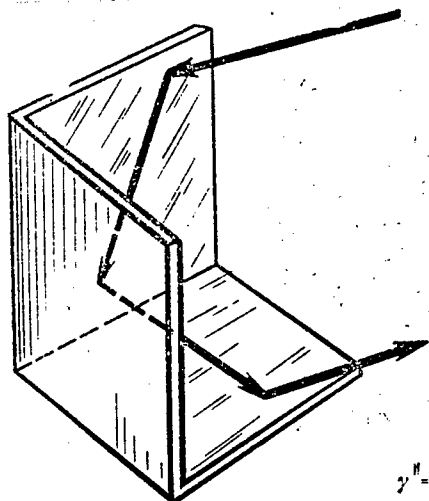
Laser Satellite Rangefinder

The idea of a laser rangefinder is exceedingly simple: the distance is determined from the measured time interval during which a light pulse, sent by the rangefinder, reaches the satellite, and being reflected, returns to the observation station. The speed of light is well known and therefore it is not difficult to compute the distance to the satellite. Strictly speaking, the operation of ordinary pulsed-light rangefinders is based on this principle. But in measuring distances to satellites, when the light pulse must travel thousands of kilometers, the energy losses are extremely great. An insignificant fraction of the initial energy of the pulse is returned to the rangefinder and it is difficult and sometimes simply impossible to register this. The difficulty could be overcome by means of lasers, capable of emitting powerful narrowly directed light pulses.

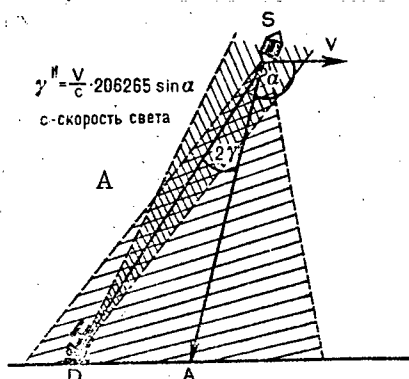
The lasers employed in satellite rangefinders emit an energy of 1-5 J during exceedingly short time intervals usually not exceeding several tens of nanoseconds ($1 \text{ nanosecond} = 10^{-9} \text{ sec}$). In this time a power of 100 MW or more is developed. The divergence of the laser beam is usually 2-5 Mrad ($1 \text{ mrad} \approx 3.4'$). The beam can be made still narrower, but then complexities arise in pointing the laser beam on a rapidly flying satellite.

In order for the light pulse to be reflected in the direction of the observation station, the satellite carries corner reflectors. A corner reflector is a system of three mutually perpendicular reflecting surfaces (usually

the three surfaces of a prism with total internal reflection). A light ray incident on it experiences three reflections and emerges in a direction opposite the incident beam. On geodetic satellites designed for laser rangefinder observations there are panels with corner reflectors and sometimes they cover the entire satellite surface.



Path of rays in corner reflector formed from three mutually perpendicular mirrors.

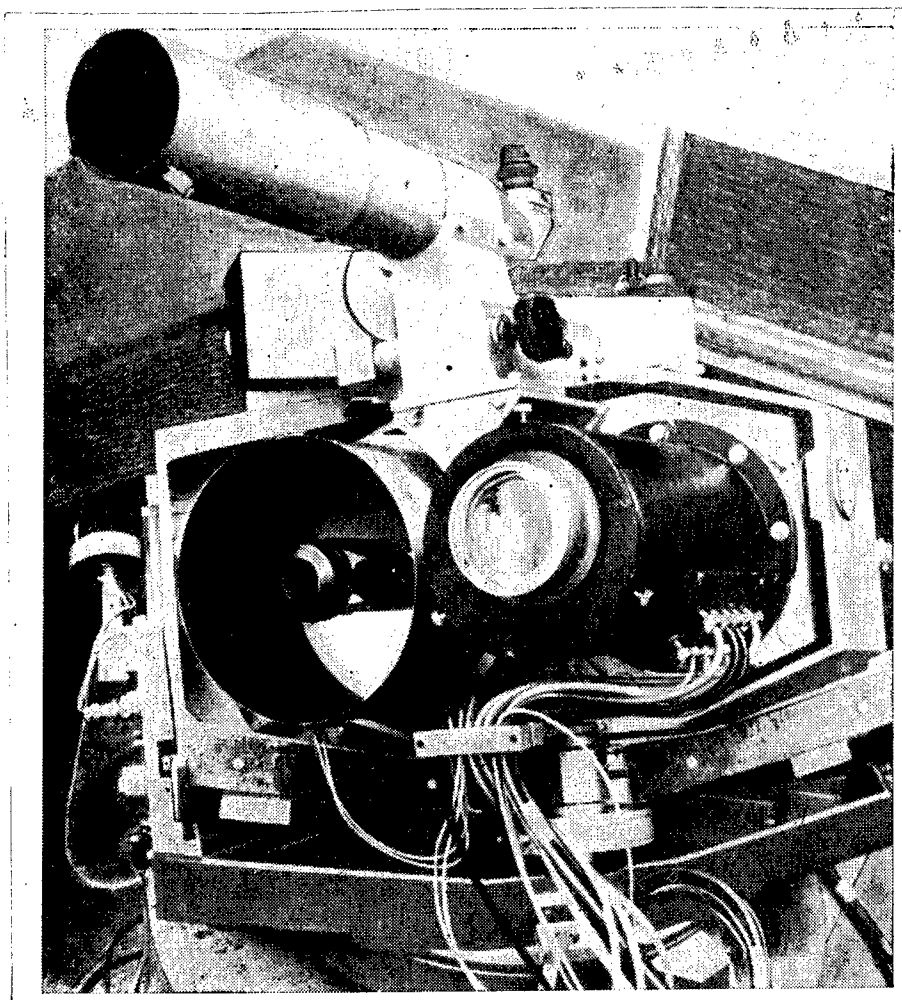


The aberration of a light pulse of a laser satellite rangefinder. The laser beam DS, being reflected from the satellite S, which is moving at the velocity V , is deflected by the angle 2γ and is returned to the point A. It is displaced from the rangefinder in the direction of satellite motion. Due to the divergence of a reflected laser beam the rangefinder is within the "laser spot." A) c = speed of light

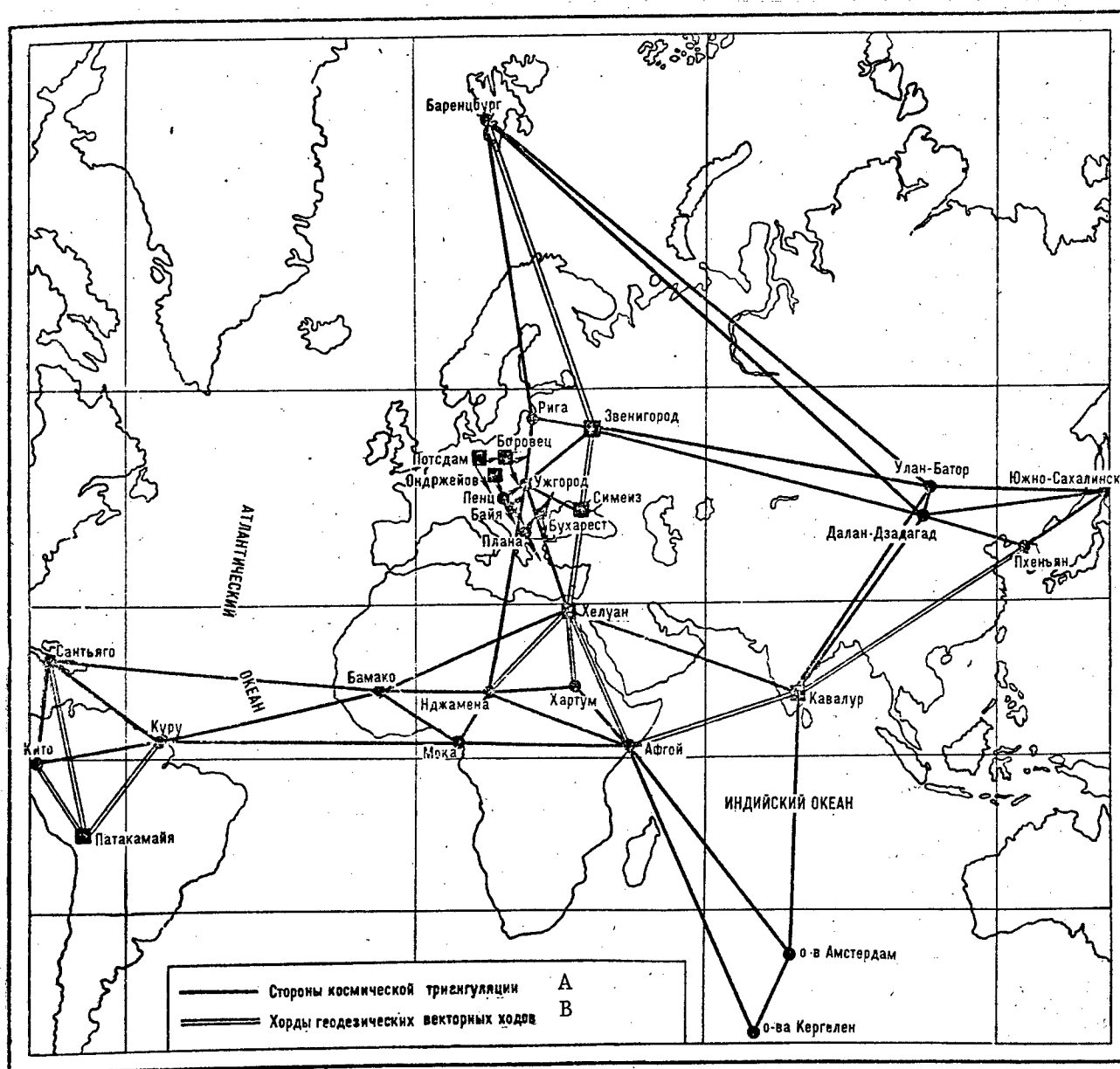
Due to the aberration of light it is impossible to achieve excessively narrow reflected beams. According to the theory of relativity, one and the same light beam in two reckoning systems moving relative to one another has dissimilar directions. The angle between the two directions is the greater the greater is the velocity of relative motion of the reckoning systems.

A corner reflector on a satellite (a system moving relative to the light source) receives the laser beam deflected by some angle γ in comparison with its direction to the rangefinder (coordinate system related to the light source). The beam is reflected in the direction opposite to that which is received by the corner reflector. But in the coordinate system

of the rangefinder, which now must be regarded as moving relative to the light source, the satellite, the beam is deflected once more by the same angle γ . The total deflection of the beam is double the aberration angle 2γ , which for low, rapidly flying artificial earth satellites can exceed $10''$. And this means that if the laser beam is strictly parallel it would not return to the rangefinder, but to a point displaced forward in the direction of satellite motion by tens of meters (for satellites flying at an altitude of 5,000 km the deflection can attain 200-400 m). However, the light is not reflected from the corner reflectors in a parallel beam, and divergence of a reflected beam by even 1 mrad creates on the earth's surface a "spot" which is probably intercepted by the rangefinder (a beam with a divergence angle of 1 mrad at a distance of 1,000 km forms a circle with a diameter of 1 km).

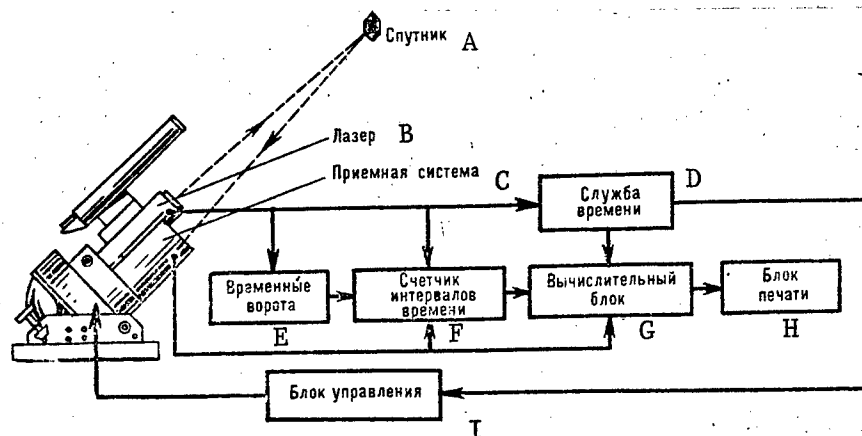


"Interkosmos" laser satellite rangefinder.

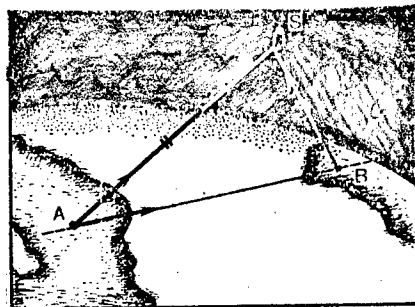


Space triangulation network created on basis of international cooperation between the Astronomical Council USSR Academy of Sciences and scientific institutions of foreign countries. All network stations are outfitted with satellite cameras. Laser satellite rangefinders have been installed at the stations designated by small squares. A) Space triangulation sides; B) Chords of geodetic vector traverses

The signal reflected from the satellite is received by a reflecting telescope with a mirror diameter from several decimeters to a meter.



Block diagram of laser satellite rangefinder. A) Satellite; B) Laser; C) Receiving system; D) Time service; E) Time gates; F) Counter of time intervals; G) Computer unit; H) Printout unit; I) Control unit



Determination of direction and length of geodetic vector. By carrying out simultaneous photographic observations of a satellite from stations A and B and laser rangefinder observations from station A, it is possible to compute the direction of the vector AB and the angles A and B. By solving the triangle ABC it is possible to find the length of the vector AB.

As already mentioned, a very weak signal is returned to the rangefinder receiving system. In order to discriminate it against the general background of sky radiation it is necessary to use narrow-band interference filters. They transmit the radiation only of that frequency which the laser pulse has and cut out virtually all other radiation. Bursts of background radiation at the frequency transmitted by the filter are controlled by time gates. This device opens a path for the signal to the recording apparatus only in that brief time interval when in accordance with computations the signal reflected from the satellite should be returned. Such a double (with respect to frequency and time) filtering of interfering radiation makes it possible to increase the response of the rangefinder recording system.

The pointing of the rangefinder on the satellite is ensured by mountings which can be classified as two principal types. A four-axis mounting makes it possible to guide the "aiming point" of the rangefinder automatically

along a small circle of the celestial sphere best approximating the apparent path of the satellite. Precise pointing on the satellite is accomplished by the observer, who continuously tracks its motion in a telescope guide. Three mounting axes serve for setting the fourth axis in such a way that tracking of a satellite can be accomplished by turning the rangefinder only around it.

In another type of mounting there are two axes (horizontal and vertical). An electronic computer is used in computing, on the basis of the orbital elements of a satellite, entered in sufficient time into its memory, the angles of rotation about the axes and this ensures the pointing of the rangefinder on the satellite without visual monitoring by an observer. Such a mounting can be employed for observations during the daytime during periods when the satellite is in the earth's shadow and is not visible.

The purpose of rangefinder observations is measurement of the distances to a satellite with an accuracy to tens of centimeters and for this it is necessary to register the time intervals between the moments of transmission and return of a light pulse with an accuracy to 5 nanoseconds or more. The resolution of modern time interval counters is still higher and attains a fantastic value -- hundreds of picoseconds ($1 \text{ ps} = 10^{-12} \text{ sec}$). In order to visualize the accuracy of time interval counters we note that 100 picoseconds is approximately the same number of times less than a second as a second is less than 300 years!

The time interval counter is activated at the moment of escape of the light pulse from the laser and a signal is immediately fed to the "time gates." Directly before the calculated moment of pulse return the "time gates" trigger the rangefinder receiving system, which at the moment of arrival of the reflected pulse stops the counter. The computed interval, and also the moment registered by a quartz clock with an accuracy to 0.1 millisecond ($1 \text{ ms} = 10^{-3} \text{ sec}$), are fed to the computation unit and then to a printout device.

However, the accuracy in determining distance is influenced to a considerable extent by pulse duration. If the maximum possible distances are measured, virtually all the energy of the light pulse is expended in space and only individual photons enter the rangefinder receiving system. It is impossible to determine when the returning photon was emitted: at the beginning or at the end of the pulse. Accordingly, the measured distance is characterized by a greater uncertainty the more prolonged is the radiated pulse. In modern laser satellite rangefinders the pulse duration does not exceed 10-20 nanoseconds and in the future will be still shorter.

We have already mentioned that several "Interkosmos" laser satellite rangefinders have been set up at stations which are participating in international studies under satellite geodesy programs. These are rangefinders with a four-axis mounting with a 32-cm Cassegrainian reflector and a 10-cm guide (field of view $1-2^\circ$). The pulse energy is 1 J, pulse duration is 15 nsec,

and pulse repetition rate is one pulse per second. The divergence of the laser beam is 3 mrad, but by means of a transmitting optical system can be narrowed to 0.5 mrad. The resolution of the time interval counter is 5 nanoseconds. In the near future plans call for the accuracy in pointing the rangefinder to be increased to 1 mrad, pulse duration -- to two nanoseconds, frequency -- to three pulses per second, and resolution of the time intervals -- to 300 picoseconds.

"Great Chord"

The accuracy in measuring distances which is ensured by the "Interkosmos" rangefinders made possible a new approach to the problem of creating a global network of geodetic control points. In 1969 Professor I. D. Zhongolovich proposed a plan for a geodetic vector traverse. A chain of geodetic vectors is constructed on the earth's surface by means of photographic and laser rangefinder observations of satellites. Their ends are observation stations situated at distances of 2,000-3,000 km apart. Each of the vectors establishes a geodetic connection between two stations. This means that if the coordinates of one of them are known (or stipulated), the coordinates of the second can be computed. The next vector, joining the second station, makes it possible to determine the coordinates of the third station, etc. In the long run, by taking a small number of steps, it is possible to achieve a geodetic connection of points situated on different sides of the earth and to measure terrestrial chords whose lengths are comparable to the earth's diameter.

A geodetic vector traverse is run in two stages. In the first stage on the basis of synchronous photographic observations it is possible to determine the directions of geodetic vectors. In this case the minimum number of observed satellite positions on each vector is two. However, in order to increase the reliability of the results and eliminate the influence of random errors several tens of observations are used for computations. The length of the vectors is measured in the second stage of the work. Synchronous photographic observations are made at two stations limiting the vector and laser rangefinder measurements are made using at least one station.

Now specialists of a number of countries participating in the "Interkosmos" international cooperation program are running two geodetic vector traverses: Arctic-Antarctica and East-West. The entire program, called the "Great Chord," provides for the computation of two terrestrial chords. One of them extends from the Spitzbergen Archipelago to the islands in the Indian Ocean and the second joins the Far East and Latin America. The work is being coordinated by the Astronomical Council USSR Academy of Sciences.

Synchronous photographic observations have already supplied researchers with material adequate for determining the directions of most vectors. Synchronous photographic and laser rangefinder observations of geodetic satellites have begun and their results will make possible a full solution of the problem.

Laser rangefinder observations, in many respects more precise than position photographic observations, make possible a new approach to solution of problems in geodynamics and celestial mechanics. By systematically determining the coordinates of points on the earth's surface with a high accuracy, it is possible to study tectonic movements, earth tides and local deformations of the earth's crust; it will be possible to study movements of the earth's continents and the earth's rotation, to refine the parameters of the earth's gravity field and variation of this field, caused, for example, by tides. It can be asserted with boldness that the practical introduction of laser satellite rangefinders has meant the onset of a new period in all research related to observations of artificial earth satellites.

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